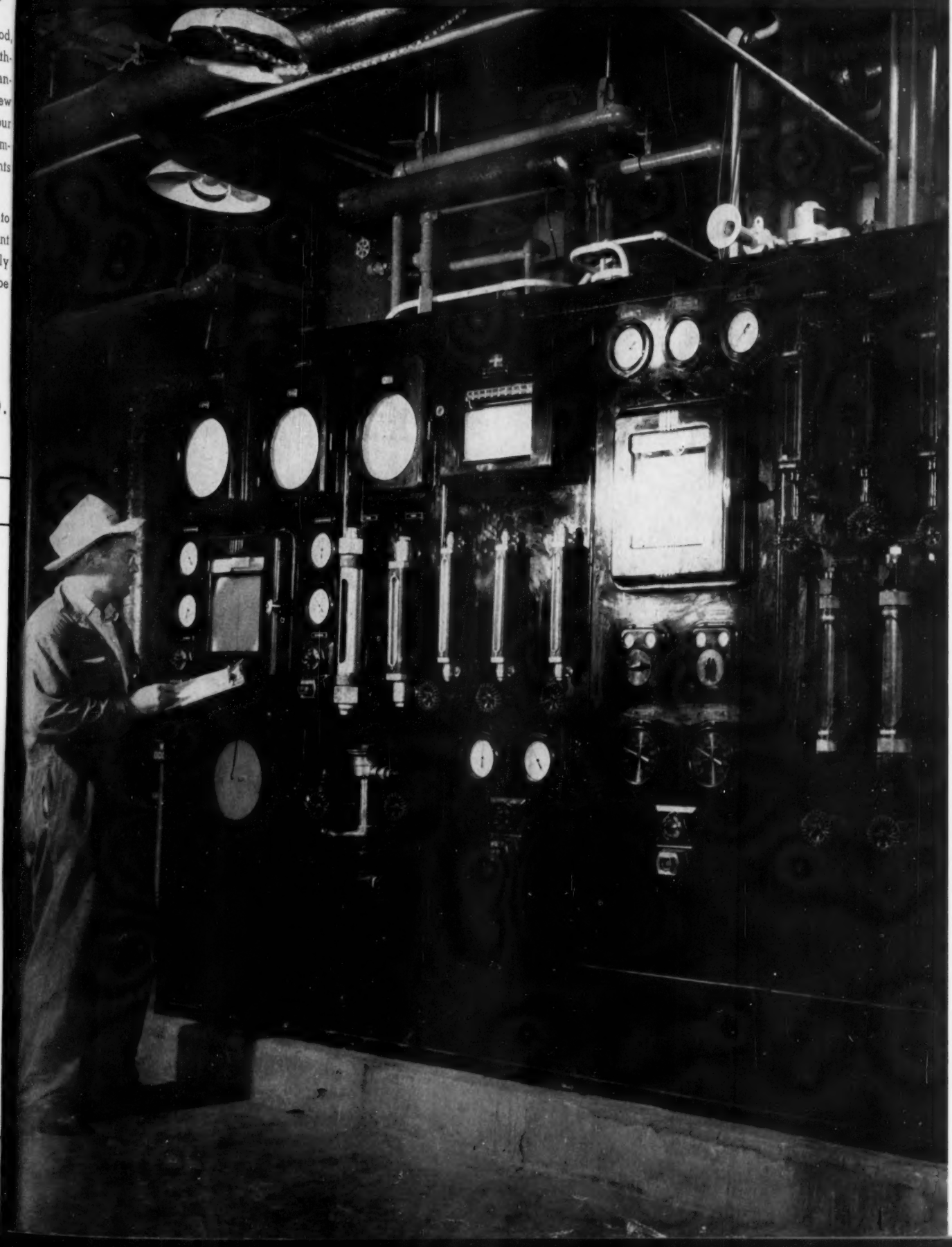
PR. 1947
. 20 No. 4

Instruments

HE MAGAZINE of MEASUREMENT and CONTROL



TAG Temperature and Pressure Recorders have been a yardstick for quality, accuracy and ruggedness for many years. They are available in many types, each helping to lower processing costs through better processing efficiency. You are invited to correspond with TAG engineers on the best way to solve your temperature and pressure problems. Write today for the TAG Recorder Catalog.

THERE'S A TAG RECORDER To Fill Your Requirements

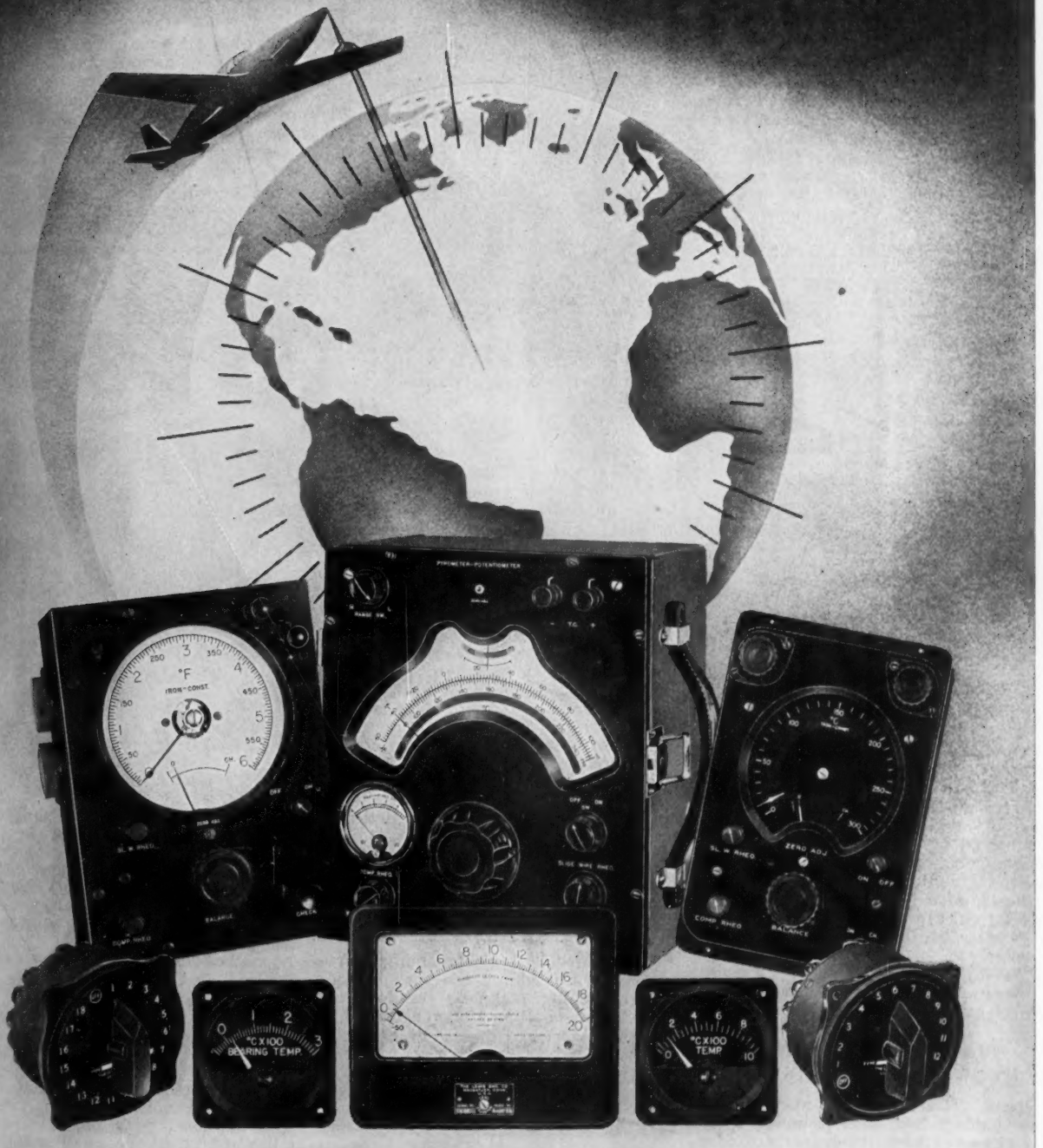
TAG Temperature Recorders are made in the following types: MERCURY, with range between −40° and +1000°F.; FULLY COMPENSATED MERCURY, range between −40° and +1000°F.; VAPOR TENSION, range between −20° and +500°F.; and GAS-FILLED, range between −60° and +800°F. All with 9, 10, or 12-inch Charts.

TAG Pressure Recorders cover the full range of pressures. Springs are available in bronze, steel, stainless and other alloys suited to the service requirements.

TAG

C. J. TAGliabue Division

PROVEN *around the* WORLD *for* ACCURACY



THE LEWIS ENGINEERING CO.

Specialists in Engine Temperature Measurements

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• POTENTIOMETERS • • • • • • SELECTOR SWITCHES • • • • • • • • • • THERMOCOUPLES •
• PYROMETERS • • • • • • RESISTANCE THERMOMETERS • • • PROTECTION TUBES •

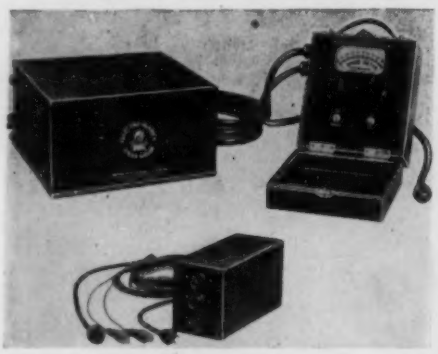
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 387.

Vehicle-speed-measuring Roadside Radar

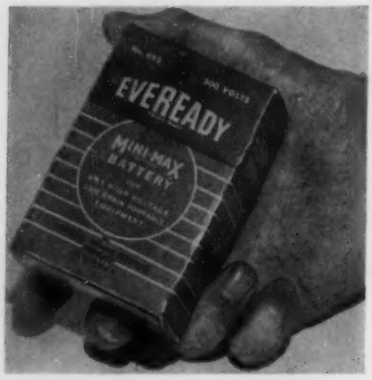
New "Electro-Matic Speed Meter" determines speed of cars on streets and highways for enforcement of speed limits, but can be used for many applications in addition. Placed in a car parked inconspicuously, it indicates or records speeds of approaching cars without their drivers' knowledge. One man can operate equipment, which weighs about 45 lbs. including carrying case. It operates from a 6-volt automobile storage battery or 120-volt a.c. Principle: microwaves are beamed at a car coming toward or going away from instrument. Radiation is reflected back to transmitter-receiver and operator can read vehicle's speed directly on the linear scale. If desired, a strip-chart recorder may be connected. Instrument will "clock" cars at speeds from 0 to 100 mph., accuracy within 2 mph. Operating zone extends for about 150 feet in front of TR unit, which may be placed virtually out of sight and connected by cable to indicator-amplifier unit and power unit (and recorder when graphic evidence is desired). "Electro-Matic Speed Meter" may be set up quickly and is ready for operation after a brief warm-up.—*Automatic Signal Div., Eastern Industries, Inc., Norwalk, Conn.*



Please mention number 401 when filling out card

1-lb. 300-volt Battery for Instruments

New "Eveready No. 493" 300-volt dry battery is the most powerful for its size ever put into quantity production, is 2-11/16" long, 2-11/32" wide and (including flush-mounted pin jack terminals) 3 15/16" long; weighs 1.1 lb. Typical application is a portable radioactivity meter which operates on 900 volts (three batteries). If used daily in this instrument for an average of four hours a day, battery life is at least 350 hours. Another field is in portable photoflash where a set of six batteries giving 1,800 volts and weighing 6.6 lbs.



provides sufficient electric energy for at least 2,500 flashes in multiple-flash gas-discharge tubes when used at rate of 20 flashes a day uniformly spread over one two-hour daily period. Other uses, photo-multiplier tubes; small light-weight insulation testers; bias supply in high-gain d-c. amplifiers; bias supply in voltage regulator circuits and other applications requiring high voltage at drains measured in microamperes.—*National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.*

Please mention number 402 when filling out card

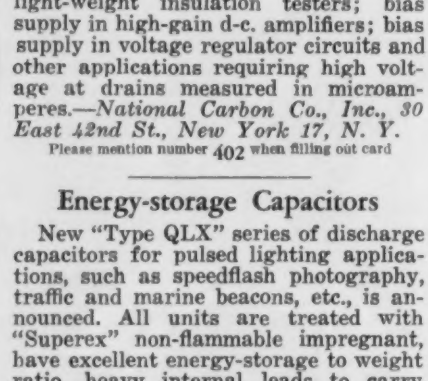
Energy-storage Capacitors

New "Type QLX" series of discharge capacitors for pulsed lighting applications, such as speedflash photography, traffic and marine beacons, etc., is announced. All units are treated with "Superex" non-flammable impregnant, have excellent energy-storage to weight ratio, heavy internal leads to carry high discharge currents, low inherent inductance, and special construction to minimize discharge stresses. — *Solar Mfg. Corp., 285 Madison Avenue, New York 17, N. Y.*

Please mention number 403 when filling out card

D-c. Amplifier

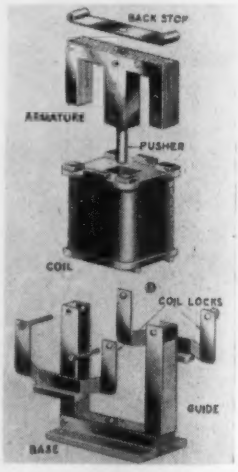
New "Model BL-913" d-c. amplifier is especially suited for use with maker's "Direct-inking Magnetic Oscillograph" (*Instruments*, June 1945, page 422). It has a frequency response from d-c. to 100 cps. and a sensitivity of 1 chart mm. per mv. other characteristics: stability, 1 chart mm. pen drift or less per hour; voltage gain, approx. 1000 times; power requirements, 105 to 125 volts 60 cycles, 125 watts; input impedance 10 megohms; input voltage range 0.001 to 200 volts; dimensions, 17¼" long × 11" wide × 7½" high; net weight, 33 lbs.; balancing to position pen electrically to any position on chart. —*Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.*



Please mention number 404 when filling out card

Solenoid

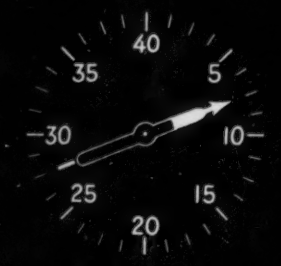
New "Practical" solenoid is of radically new design, consisting of only five component parts—base armature coil, coil locks and back stops (see exploded view.) Armature is designed with a self-contained built-in pusher which makes new unit adaptable to push or pull work.—Voltage rating of each coil is clearly indicated by a lead wire color code.—*Practical Electric Co., 4505 Oakwood Blvd., Melvindale (Detroit) Mich.*



Please mention number 405 when filling out card

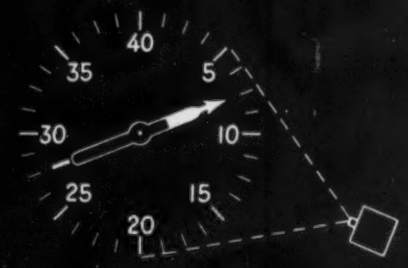
UHF Signal Generator

New "Model 616A" UHF Signal Generator is a laboratory standard said to be the first instrument of its kind to provide direct-reading frequency and voltage scales, simplified controls, c-w., f-m., pulsed or delayed pulse output, in one small well-planned unit. It utilizes a resonant-cavity reflex-klystron oscillator whose r.f. output may be directly set and directly read, either in microvolts or db, on a simplified output dial. Any frequency between 1800 and 4000 Mc. is instantly available on large central tuning dial. It is not necessary to make voltage adjustments when frequency is changed: a coupling device developed by maker causes oscillator repeller voltage to



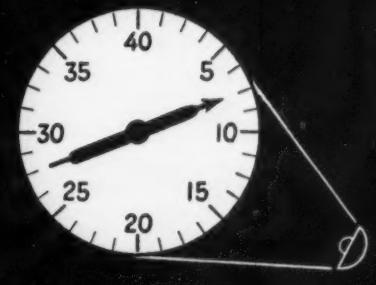
Self-Luminous

– Radioactive markings and pointers shine brightly in darkness, are clearly readable without use of any outside light source.



Fluorescent – Fluorescent markings and pointers shine brightly under ultraviolet radiation. Brightness is controllable.

Phosphorescent – Phosphorescent markings and pointers have a useful afterglow following activation by ultraviolet or visible light.



Nonluminescent – The U. S. Radium Corporation has complete facilities and skilled personnel for the production of high-precision dials.

Which type of dial best meets your need?

Whether your primary interest is accuracy, handsome appearance, low cost, or clear readability in daylight, artificial light, or darkness – or a combination of any or all of these characteristics – the United States Radium Corporation is prepared to meet your dial requirements exactly.

The many thousands of U. S. Radium dials in service in aircraft, industrial, and scientific instruments testify the quality and satisfaction *you* can expect when you specify "U. S. Radium dials and pointers".

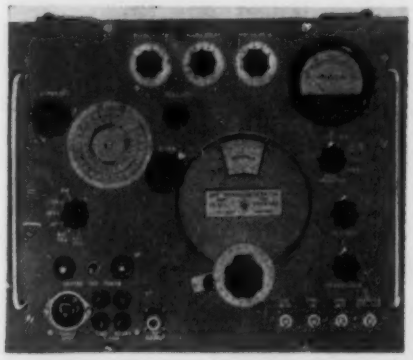
Tell us what kind of dial you're interested in, and we'll send you a sample from our current production. Write *Dept. G7, United States Radium Corp., 535 Pearl Street, New York 7, N. Y.*

OTHER PRODUCTS OF U. S. RADIUM

- **RADIOACTIVE FOILS** *(alpha-ray ionization sources)*
- **IONOTRON STATIC ELIMINATORS** • **RADIUM LOCATORS:** *pendants, lenses, buttons, screws, markers*
- **LUMINOUS RETICLES** *and other specialties*
- **POWDERS:** *cathode-ray tube and television tube*
- **SILHOUETTE ILLUMINATION** *of clocks, watches and instruments*

US RADIUM

UNITED STATES RADIUM CORPORATION



automatically track all frequency changes. Accuracy of frequency calibration is within ± 1%, and stability is of the order of 0.005%/°C. R-f. output ranges from 0.1 volt to 0.1 microvolt, or 7 dbm. to 127 dbm. R-f. is available in c-w., pulse-modulated and limited f-m. modulation at power-supply frequency. Modulation may be pulsed internally or externally. Internal pulsing may be accurately synchronized with positive or negative external pulses; or it may be delayed from 3 to 300 microseconds. — *Hewlett-Packard Co., Palo Alto, Calif.*

Please mention number 406 when filling out card

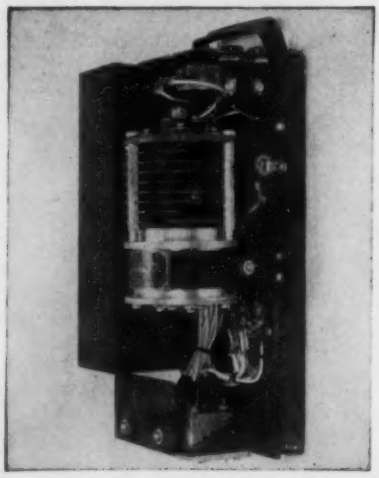
Miniature Capacitors

New "Miniature Capacitors 63P and 64P" withstand adverse humidity conditions; maintain high insulation resistance; are manufactured in both round and flat types. Standard units range from 0.00025 to 1.0 mfds. A typical capacitor rated 0.005 mfd. at 150 volts is ¾" long × 3/16" diameter. Insulation resistance at 25°C. after a 2-minute charge at 180 volts d.c. is such that product of capacitance in μfd. and insulation resistance in megohms is not less than 1,000, except that the insulation resistance of any capacitor need not exceed 10,000 megohms. Power factor at or referred to 1,000 cycles is not more than 2%.—*Sprague Electric Co., North Adams, Mass.*

Please mention number 407 when filling out card

Aircraft Voltage Regulator and Control Panel

New "Type AVP-9" voltage regulator and control panel designed for aircraft d-c. power systems provides stable regulation, equalized load division, maximum continuity of power, as well as safety, reliability and long service life. Complete assembly weighs 5 lbs., consists of carbon-pile regulator, field relay, equalizer relay, ballast lamps, two differential cut-out relays, panel structure with plug-in type receptacle, and an overvoltage relay. Panel is arranged with a plug connector for ease of installation of shock mount in airplane.



All maintenance, testing and adjustment can be performed at service bench. — *Aviation Division, Westinghouse Electric Corp., Lima, Ohio.*

Please mention number 408 when filling out card

Aircraft Smoke Detectors

New aircraft smoke detectors for detection of fire in baggage and cargo compartments weigh less than 2½ lbs., utilize "reflection" principle: whenever smoke appears in a beam of light inside detector, light is reflected by smoke particles onto a photocell, sounding an audible alarm and flashing a red light on instrument panel to show exact location of fire. Operation may be checked at any time by a "test" switch (located on instrument panel) which also provides for resetting after operation or test. Two types are available: natural-convection type detector requires no tubing and blower or other exhaust means; tube type requires use of tubing, blower or small clamshell. Both are on list of CAA-approved devices.—*C-O-Two Fire Equipment Co., P. O. Box 390, Newark 1, N. J.*

Please mention number 410 when filling out card

Germanium Varistors

New four-element germanium varistors said to provide improved stability, long life and reduction of component capacitance in comparison with vacuum-tube and other types of rectifiers for modulation use. Point-contact reduces capacitance to a few micro-microfarads and extends useful frequency range. "Type V-301," a plug-in unit, contains four selected and balanced germanium crystal diodes, is mounted in metal shell, 2-15/32" overall × 1.312" diameter, with 8-pin octal base. "Type V-307" has solder type terminals for top or sub-panel mounting. Electrical characteristics of both are the same. Diodes are selected for forward resistance of 85 to 120 ohms at 1.5 volts. Diode pairs are balanced at 1.5 volts to within 2 ohms. Modulator ratings for each of the four diodes: maximum inverse voltage, 25 volts; maximum average current, 20 ma.; maximum peak current, 40 ma.; maximum instantaneous surge current, 50 ma. — *Electronics Div. Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y.*

Please mention number 411 when filling out card

Direct-reading Spectrometer

New "Baird Associates-Dow Direct-reading Spectrometer" provides rapid and completely automatic analysis of various elements in an alloy by measuring automatically the intensity of spectrum lines. It obviates need for photographic and developing equipment and eliminates film-emulsion-variation errors. Only one technician is required to operate instrument, as source, spectrometer, and measuring system are integrated into one compact unit. Samples can be run at a rate of 4000 per month (approx. 20,000 quantitative determinations). Individual spectrum lines necessary for analysis can be isolated even in complex iron spectrum, and their intensity measured with electron-multiplier phototubes. Tube output charges a capacitor which, after sparking period, discharges into a meter reading directly in percentage concentration of the alloying and residual constituents. — *Baird Associates, 33 University Road, Cambridge, Mass.*

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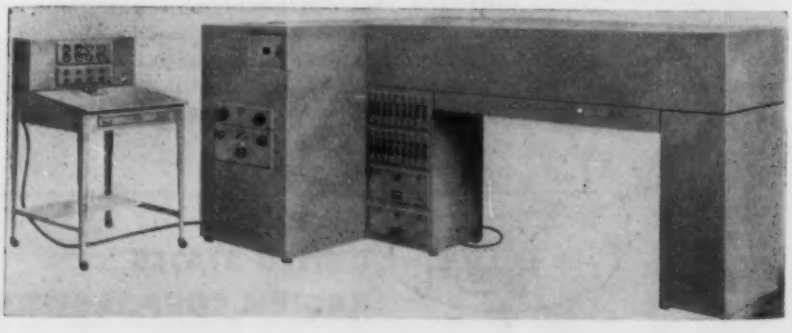
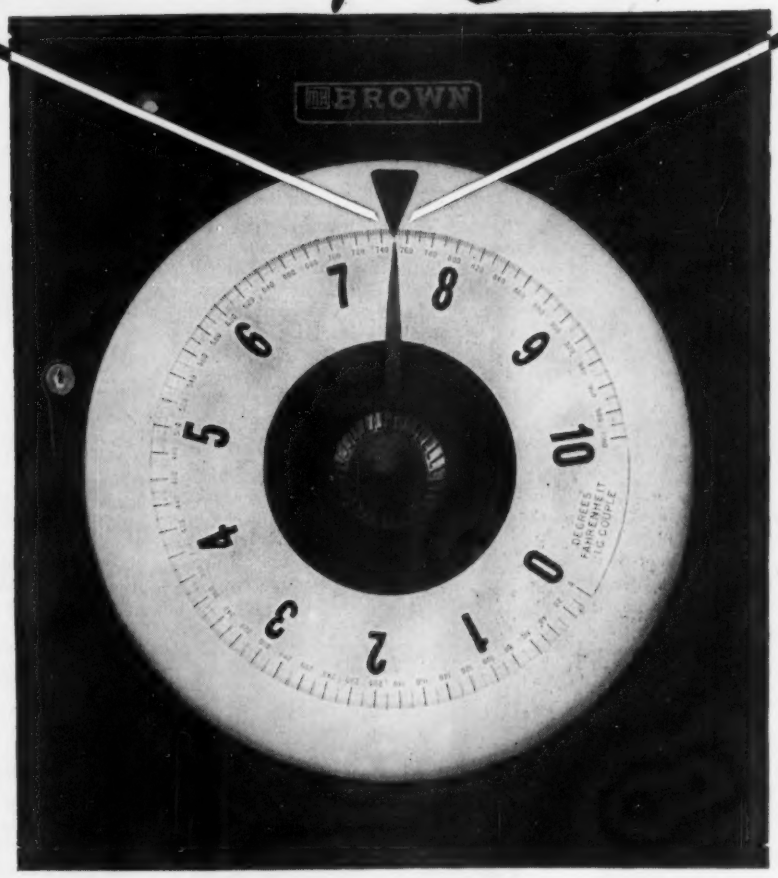


Control for D-c. Motors Operated from A.c.

New "Noark Electronic Motor Control" for operating d-c. motors from a-c. power is available in two models, one a general-purpose reversing type

You Read Temperatures *At Top Center*



ON THIS *NEW* INDICATING CONTROLLER

Here's a potentiometer controller designed and built for heavy duty—with a unique operation feature never before offered.

Look at the 28⅝" scale with ⅞" black numerals on a white field, easily readable at distances up to 60 feet. And, because the scale turns to the fixed pointer (rather than the pointer moving over the scale) temperature readings are always at the top center "12 o'clock" position.

The large external control index setting knob permits easy and accurate setting of the control point.

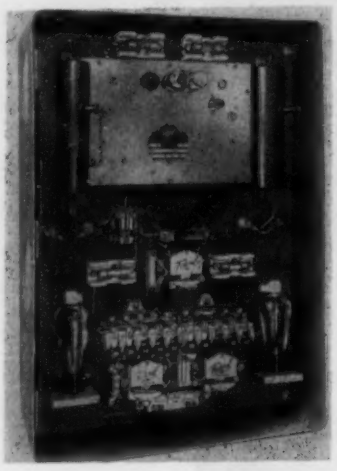
Inside, the instrument is a masterpiece of design. The few moving parts move only during a temperature change. A simple two-part mechanism operates *Con-Tac-Tor* glass enclosed mercury control switches which are unaffected by dirt, dust or corrosive atmospheres.

The new Brown Electronik Potentiometer is inexpensive in first cost and maintenance. Both inside and outside it is designed and built to do its job long and well. For detailed description write for illustrated catalog. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Company,* 4482 Wayne Avenue, Philadelphia 44, Pa. Offices in all principal cities.

TORONTO, CANADA LONDON, ENGLAND AMSTERDAM, HOLLAND BRUSSELS, BELGIUM STOCKHOLM, SWEDEN

BROWN *Electronik* POTENTIOMETERS

applied to a 2-hp. 230-volt d-c. motor; the second a special control for "Abrasive M-3 Surface Grinder." Motor speed is closely regulated to provide an almost flat speed torque curve with changes in load having little effect on speed. For any speed setting, it is said, performance is practically equal to that of a synchronous motor even with a suddenly applied load. Automatic current limiting makes it possible to preset maximum allowable armature current: Even with armature locked



mechanically and speed setting at maximum, current value is not exceeded. Stepless acceleration from standstill is possible without drawing excessive current from the line.—*Federal Electric Products Co., 50 Paris St., Newark 5, N. J.*

Please mention number 412 when filling out card

Torque Measuring Device

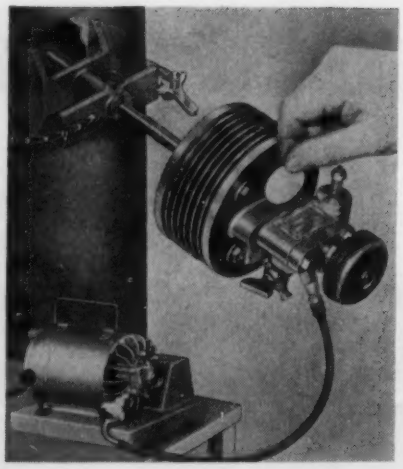
New "Model SDB-25 Beam Scale" for checking accuracy of torque tools, etc., is accurate to a fraction of an inch-

pound; has 25 in.-lb. capacity which can be varied by repositioning regulating weight. Various adapters are made to suit special applications. Weight, 10¾ lbs.—*Airdraulics Engineering, Inc., New Canaan, Conn.*

Please mention number 413 when filling out card

Smoke Density Tester

New "Smoke Tester" is designed primarily for testing density of oil-burning furnace smoke. It comprises a sampling unit attached to furnace smoke pipe and a motor-driven vacuum pump. A time switch automatically stops motor after a one-minute interval, during which smoke carried along in flue gases sampled by sampling unit is evenly deposited on a filter disk, producing a visual indication: exposed area of the filter disk will vary from light gray to black. Immediately after the pump stops, filter disk is removed

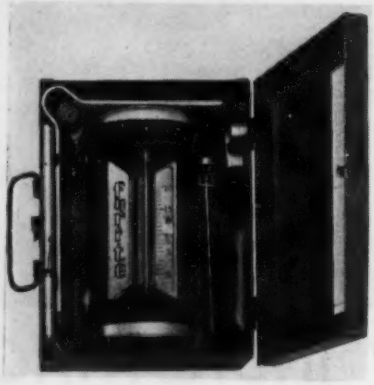


from holder and compared with disks on a comparator scale furnished with instrument. This matching procedure enables user to adjust burner to give highest percentage of CO_2 without objectionable smoke.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Penna.*

Please mention number 414 when filling out card

Combustion Service Kit

New model of "Fyrite Combustion Service Kit" has two new features: (1) metal case with metal handle and snaps; (2) all-metal dial thermometer,

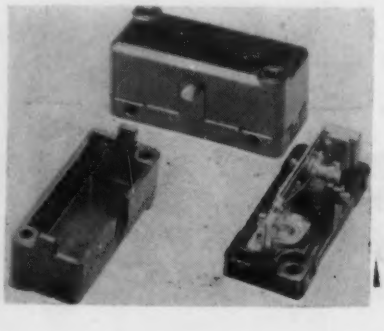


100° to 950°F. range, optional equipment in place of mercury-in-glass thermometer, affords easy readability even in dim light, handling convenience and elimination of breakage hazards.—*Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh 8, Penna.*

Please mention number 415 when filling out card

Limit Switch

New "Amptrol" precision snap-action limit switch features low actuating pressure (¼ oz.) and short-travel differential (0.003") with high load

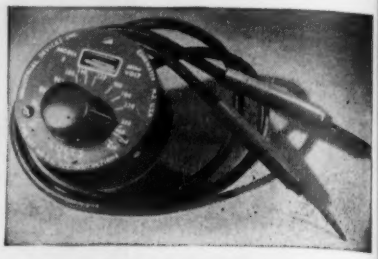


capacity (interruption capacity adequate to permit safe direct control of motors up to 1/3 h.p. rating). Over-all dimensions 1-25/32" long, 25/32" wide, 15/16" high; weight 1 oz. Switch is said to be ideally suited for direct operation by bimetal elements, bellows, etc.—*Friez Instrument Div., Bendix Aviation Corp. Baltimore 4, Md.*

Please mention number 416 when filling out card

Neon-glow Voltmeter

New "Mini-Volt" midget neon-glow instrument indicates a-c. or d-c. voltage, is immune to mechanical and electrical abuse, is virtually burnout-proof. Cal-



ibrated for use on a-c. from 65 to 660 volts, with an impedance of approximately ½ megohm, it is operated by turning knob until neon glow extinguishes, whereupon voltage is read on scale. For d-c., which is indicated when only one electrode of neon indicator glows, reading is multiplied by 1.15. Instrument may be used to check whether lines are 110, 220 etc., to find blown fuses, to check overloaded lines, to measure plate voltages in radio work and for checking leakage.—*Industrial Devices, Inc., 22 State Road, Edgewater, N. J.*

Please mention number 417 when filling out card

High-sensitivity Kilovoltmeters

New series of eight high-sensitivity kilovoltmeters is announced. All instruments are portable and draw little current from measured circuits. Illustrated

is "No. 760-A Kilovoltmeter," which has three scales of 5, 10 and 20 kv. with a sensitivity of 10,000 ohms per volt (100 ma. at full scale). Scale selection is made by connecting to the proper insulated binding posts. Another binding post provides ground connection. A polarity reversing switch is supplied and provisions are made for connecting an external instrument where required. The eight new kilovoltmeters include d-c., a-c. and a-c.-d-c. types in practically any required voltage com-

A quarter in the slot . . . and the hotel radio comes to life. The travel-weary guest can relax with exactly two hours of his favorite music. The control that times the program is operated by a Telechron synchronous electric motor.

This is only one of many applications for Telechron motors. Dependable and versatile, they have been used successfully in clocks and timing devices for 25 years—and more. New and unusual applications to automatic timing, switching, recording and control equipment are being developed constantly. Perhaps a Telechron motor is the answer to your needs.

Telechron motors are easily adapted to a wide variety of electric devices—complicated control mechanisms as well as simple switches. They're self-starting, and reach rated speed almost instantly. They operate in perfect synchronism with all commercial frequencies . . . *can't run faster or slower*. Conservative torque ratings, precision building and Telechron's exclusive oiling system assure long, trouble-free service.

A Telechron motor gives your product the extra sales advantage of Telechron leadership. For over 25 years, Telechron has been the largest producer of synchronous electric motors. Every one is Underwriters Laboratories approved. Why not let Telechron's *application engineers* study your motor needs? They'll be glad to make recommendations. Just address Motor Advisory Service, Dept. B, Telechron Inc., Ashland, Mass.

●

SEE OUR CATALOG IN SWEET'S FILE

Telechron Motors Are Now Being Used for:

Stoker, Oil Burner and Temperature Controls
Industrial Process and Cycling Timers
Business Machinery
Medical Devices
Household Appliance Timers
Musical Devices

Telechron
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SYNCHRONOUS MOTORS

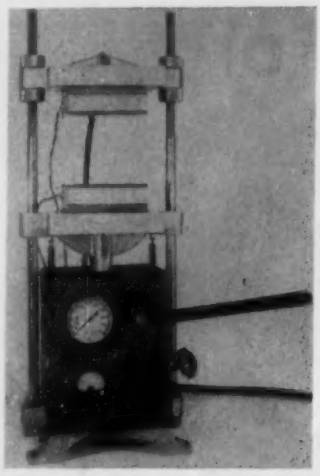
The First and Favorite Synchronous Electric Timing Motor

bination. Accuracy is 2% for d-c. measurements and 5% for a-c. measurements.—*Shallcross Mfg. Co., Collingdale, Penna.*

Please mention number 418 when filling out card

Laboratory Press

New three-ton hydraulic press is said to be ideal for schools and colleges and for plant laboratories. Floor space

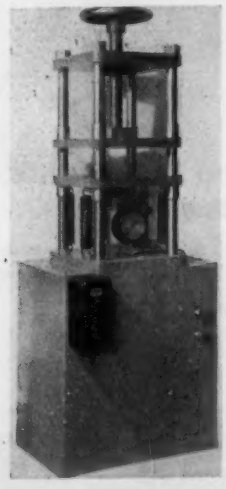


9"×12"; height 31"; weight 85 lbs. crated. Temperature controller is a bimetal thermostat; temperature indicator is a millivoltmeter mounted on metal case with 4-ft. long armored thermocouple leads. Scale 0-600°F. Platens are approx. 5½" by 8", water-cooled. Heating elements, total of 1050 watts in upper and lower platens.—*Laboratory Specialties, Inc., Wabash, Indiana.*

Please mention number 419 when filling out card

Hydraulic Press

New "Super Hi-Speed" hydraulic press has controls for ram stroke, ram speed in inches per second, speed in

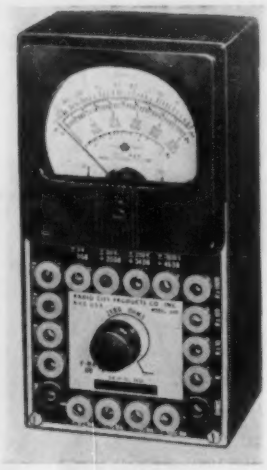


strokes per minute and pressure. Maximum stroke 6½"; six models in 25- to 50-ton capacities.—*Wroble Engineering Co., 1067 Davis Terrace, Schenectady, N. Y.*

Please mention number 420 when filling out card

Circuit Tester

New "Model 449A Multitester" has a d-c. sensitivity of 5000 ohms per volt,



employs a germanium crystal rectifier which permits a-c. measurements from 30 cps. to 50 kc. and completely eliminates all a-c. voltmeter temperature errors. Indicator is accurate to 2%. Matched metallized voltage multipliers have a tolerance of 1%. Metal case affords complete shielding. Batteries are spring-clip mounted — *Radio City Products Company, Inc., 127 West 26th Street, New York 1, N. Y.*

Please mention number 421 when filling out card

Engine-indicator C-r.o. with Synchronizing Means

New "Syncro-Marker Pressuregraph" system embodies all components of "Pressuregraph" system (see *Instruments*, April 1945, page 274; Dec. 1945,

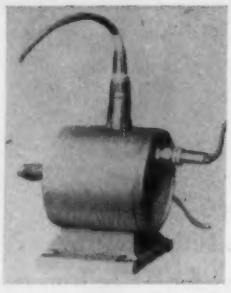


Fig. 1

page 916) plus new "Syncro-Marker" unit (Fig. 1) which synchronizes timebase sweep of oscillograph with rotation of machine under test so that repetitive pressure phenomena appear stationary; and which also adds marker signals either in 5° of engine rotation or in milliseconds measurable on screen. These reference "pips" permit new studies and facilitate conventional

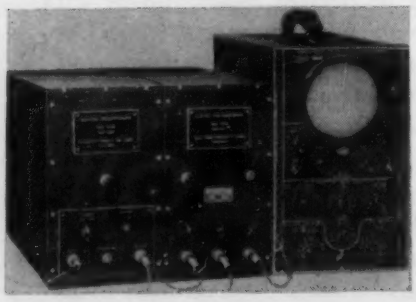


Fig. 2

studies. For example, quick check ca easily be made of spark timing, b conductively coupling in a section o spark-coil primary to c-r.o. input an then connecting capacitively a lead t high-potential c-r.o. input termina from spark plug lead. Applications other than internal combustion engine

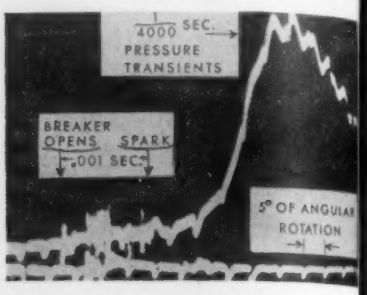


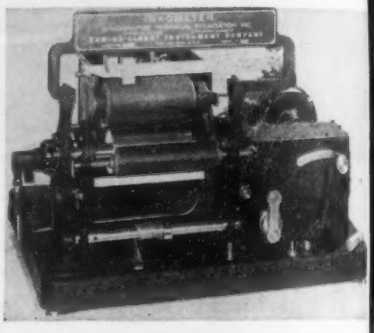
Fig. 3

include compressors, pumps; ammun tion manufacture; jet engines; fu studies; displacement of moving part —*Electro Products Laboratories, 5 West Randolph St., Chicago 6, Illinoi*

Please mention number 422 when filling out card

Ink Consistency Tester

New "Model C-46 Inkometer," fo measuring effective consistency of litho graphic and printing inks, embodie



an ink-film dynamometer: A delicately-balanced pendulum involving a hollow brass roller and a composition roller is first "zeroed" without ink; an ink sample of standard volume is applied to rollers; resistance is measured by a sliding weight on a scale beam. Standard temperature is maintained by circulating water from a thermo-regulated bath through hollow brass roller. Composition rollers may be coated with whatever material is used on ink rollers of presses. Press speeds are also simulated: "Model C-46" produces speeds of 400, 1200 and 2000 rpm., or peripheral speeds of 314, 942 and 1570 fpm.—*Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Penna.*

Please mention number 423 when filling out card

Leak Detector for Vacuum Systems

New Vacuum Leak Detector is a portable battery-operated instrument which obviates need for shutting down vacuum systems in order to detect a leak; enables anyone who can read dial to locate leak. Principle: A heated wire housed in a metal chamber, is part of a Wheatstone Bridge circuit. When a vacuum is pulled on chamber, filament

Long-distance Television is twenty years old

At the 1927 demonstration, Dr. Herbert E. Ives explained the television system developed in Bell Telephone Laboratories.

APRIL 7 is a notable day in communication history, for on that day in 1927 was the first demonstration of television over long distances. Large-scale images were flashed from Washington, D. C., by wire and from Whippany, N. J., by radio to a public demonstration in New York City. "It was," said a newspaper, "as if a photograph had suddenly come to life and begun to smile, talk, nod its head and look this way and that."

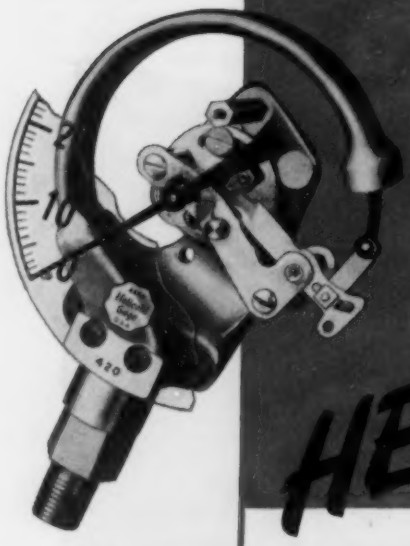
That was the first of many public demonstrations, each to mark an advance in the television art. In 1929 came color television, and in 1930 a two-way system between the headquarters buildings of A. T. & T. and Bell Laboratories. When the first coaxial cable was installed in 1937, television signals for 240-line pictures were transmitted between Philadelphia and New York and three years later 441-line signals were transmitted. By May, 1941, successful experiments had been made on an 800-mile circuit.

End of the war brought a heightened tempo of development. Early in 1946 began the regular experimental use of coaxial cable for television between New York and Washington, and a few months later a microwave system for television transmission was demonstrated in California.

Transmission facilities will keep pace as a great art advances to wide public usefulness.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING, FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

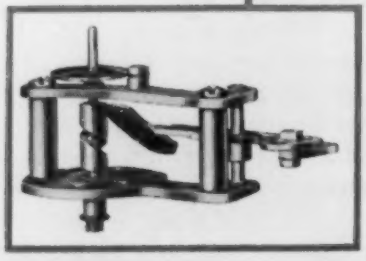


Another FIRST for HELICOID!

Now Helicoid offers pressure gages with Monel Bourdon tubes.

This is just one more advantage of Helicoid Gages. Here are some of the others:

- The Helicoid Movement, which eliminates "clock gears."
- Korex Bourdon tubes of alloy steel, stainless steel or Monel with smooth inside surface less likely to fracture.
- Fused joints for added strength where it's needed most.
- Silver brazed joints in bronze-tube models for the same reason.
- Bronze tubes of heat-treated, phosphor-bronze with silver brazed joints. (Bronze tubing costs about twice as much as brass, but has better spring characteristics.)
- Socket streamlined for easier cleaning and more equalized stress.
- Weather-proof case to keep out dust and moisture.
- These are just a few of the many reasons why large users of pressure gages are standardizing on Helicoid. Write for our technical catalog which tells the complete story.



The Helicoid Movement is one of many exclusive features of the Helicoid Pressure Gage.

ACCO

HELICOID GAGE DIVISION

AMERICAN CHAIN & CABLE

Bridgeport 2, Connecticut

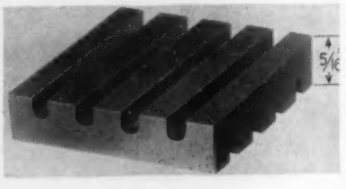
TRADE MARK

becomes slightly chilled, unbalancing bridge. Sensitivity: a leak equivalent of 0.006" water causes a ⅛" deflection of pointer. Instrument can be used equally well in detection of leaks when checking welded seams or joints on equipment under pressure. Case dimensions 3¼"×4½"×7½". Instrument is furnished with a short tube having a rubber suction cup to be applied at point of detection. — *Davis Emergency Equipment Co., Inc., 80 Halleck St., Newark 4, N. J.*

Please mention number 424 when filling out card

Vibration-absorbing Pads

New "Isomode" pads are made of oil-resistant Neoprene, are said to be designed and compounded to insure

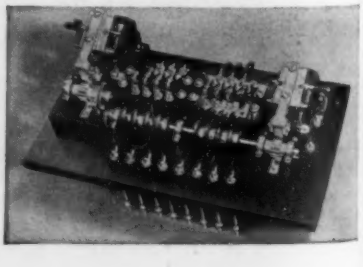


ruggedness, high efficiency and long life. Standard pads are 18" square, 5/16" thick, and can be easily cut to any size or shape desired, for mounting various sizes of equipment from a galvanometer to a tensile test machine. —*The MB Mfg. Co., Inc., New Haven 11, Conn.*

Please mention number 425 when filling out card

Reversing, Separate-circuit Multipole Sequence Relay

New "Type 96AFA" reversing, separate-circuit ratchet-operated multipole sequence relay is adaptable to applications involving addition and subtraction of loads, as in switching-in or -out individual units from a bank of capacitors. One operating coil steps cam shaft forward, a step at a time; the second



Arnold presents:

another step towards a complete line of permanent magnet materials . . . . .

CAST ALNICO I

CAST ALNICO II

CAST ALNICO III

CAST ALNICO IV

CAST ALNICO V

CAST ALNICO VI

CAST ALNICO XII

SINTERED ALNICO

SINTERED ALNICO

In general SINTERED ALNICO MAGNETS do not compete with, but rather supplement, magnets produced by the cast method to widen the scope of potential permanent magnet applications.

Alnico magnets weighing roughly one ounce or less should be produced by the sintered method.

Heavier magnets of more intricate shapes can be produced. For some applications Sintered magnets are more economical because:

1. Magnetic characteristics are practically the same as Cast Alnico.
2. Sintered Alnico is a fine-grain, homogeneous material which has more uniform flux density, is easier to grind, and provides better surface finish.
3. Sintered Alnico magnets can be produced to closer dimensional tolerances:

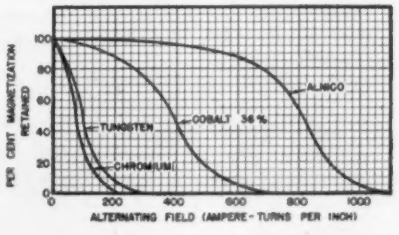
SINTERED ALNICO II	CAST ALNICO II
0.000 to 0.125 — + .005	0.000 to 2.00 — ± 1/64
0.126 to 0.625 — + .010	2.0 to 4.0 — ± 1/32
0.626 to 1.250 — + .015	4.0 to 6.0 — ± 3/64
1.251 to 3.000 — + .062	

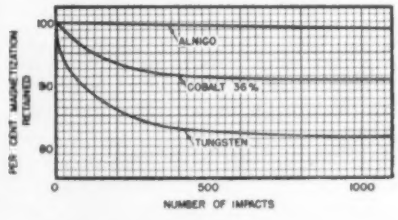
Grinding can in many applications be eliminated.

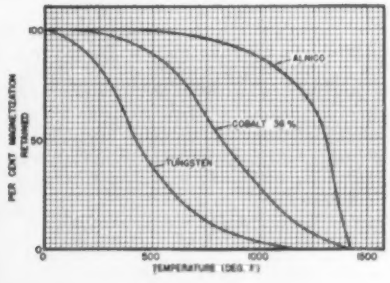
4. More intricate shapes, including holes, inserts, etc., are more feasible.
5. Transverse modulus of rupture is several times greater.

All Alnico, and particularly Sintered magnets, have very high values of Coercive Force (which is the capability of resisting demagnetization or loss of magnetism due to stray fields and from heat and vibration).

The curves show roughly the effect of these demagnetization factors on Alnico compared to other alloy steels.







THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Specialists in the manufacture of PERMANENT MAGNET MATERIALS

operating coil steps it back. Mechanical stops limit forward and reverse travel of shaft. Standard ratchets supplied have 12 teeth. Operating coils are for a-c. use only. — *Struthers-Dunn, Inc., 146-50 No. 13th Street, Philadelphia 7, Pa.*

Please mention number 426 when filling out card

Tube Testers

New "Models 305 RC and 330 RC" tube testers are new versions of company's "Models 305 and 330." The former is a standard type tester with

Fig. 1

3-way switching arrangement which permits testing any tube regardless of base connections or internal connections of elements. The other is Mutual Conductance Tube Tester announced last

Fig. 2

year. To both these instruments has been added new "No-Backlash" Roll Chart which, kept in constant tension, makes it impossible to turn selector

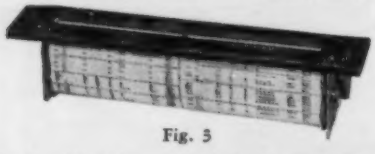


Fig. 3

wheel without moving chart. Selections can be made with a minimum of effort since gearing is such that six turns of selector wheel will run entire 12½-foot chart of "Model 305RC," and three turns on "Model 330RC."—*Simpson Electric Co., 5216 Kinsie St., Chicago 44, Illinois.*

Please mention number 427 when filling out card

Refrigerant Valve

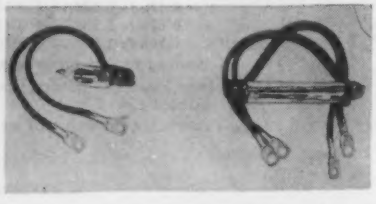
New "Tenney TS-1 Thermostatic Expansion Valve" incorporates a check valve which prevents back pressure and

bleeding suction vapor from high-temperature evaporator to low-temperature evaporator when both are connected to one suction line. This enables one compressor to service two or more evaporators without hazard of temperatures becoming equalized during machine shut-down. Compactness of unit permits application to installations in confined spaces. In effect, no installation is required, because check valve is an integral part of thermostatic valve assembly.—*Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J.*

Please mention number 428 when filling out card

Mercury Switches

New mercury switches have contacts which are always clean, cannot pit or burn; provide quick make and break action. Any contact arrangement can be furnished including polyphase types.



New switches can be incorporated in practically any equipment requiring positive switching. Multiple contact types can be supplied in a single unit.—*Chatham Electronics, 475 Washington St., Newark 2, N. J.*

Please mention number 429 when filling out card

Laboratory Furnace

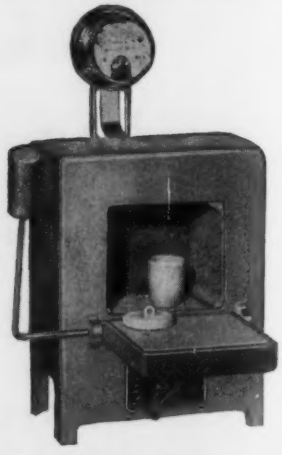
New "Model 9A De Luxe" medium-size laboratory furnace with built-in automatic temperature control is 19″×

20½″×21¼″ over-all; maintains any desired temperature automatically between 250° and 1900°F., and reaches a maximum 2000°F. Heating unit consumes 2,000 watts at 110 volts (a-c. only). Inside dimensions are 6″×6″×6″, with a 3¼″ throat additional. Complete equipment including automatic temperature control weighs 148 lbs.—*K. H. Huppert Co., 6830 Cottage Grove Ave., Chicago 37, Illinois.*

Please mention number 430 when filling out card

Laboratory Furnace

New "Model GTP" electric furnace features a stepless knob control whereby any desired temperature between 500° and 1850°F. can be selected and

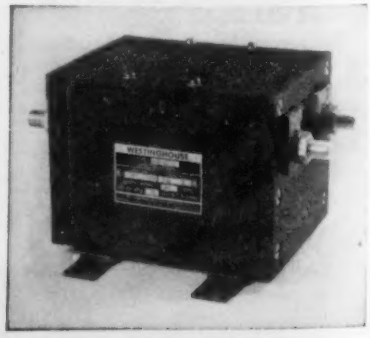


automatically maintained. This "Temco Control" is nearly 100% compensating for normal fluctuations in line voltage; is available for use on d-c. as well as a-c. of any cycle. Inside dimensions 4″ wide, 3¾″ high and 3¾″ deep. Indicating pyrometer has both F. and C. scales. Body and door are one-piece aluminum castings which make furnace portable (15½ lbs.).—*Thermo Electric Mfg. Co., 474 W. Locust Street, Dubuque, Iowa.*

Please mention number 431 when filling out card

Aircraft G-c. and G-p. Relay Assembly

New "Type AVR-32-A" main generator contactor and ground protective relay assembly, designed for aircraft d-c. power system applications, is en-



closed in a dust-, moisture- and explosion-resistant box. It weighs 3.5 lbs. Bridge type double-break contacts and inertia spring arrangement assure freedom from arcing or freezing contacts. A low voltage drop-out feature prevents malfunctioning. Ground-pro-

Brush presents

A DC Amplifier for use with Brush Magnetic Oscillographs!

This is truly a practical D.C. amplifier! It opens new uses for your Brush Direct-Inking Oscillograph. As with all Brush products this new instrument represents years of intensive research in engineering and design. Write today for the complete story . . . Brush representatives will be glad to demonstrate.

Specifications include

- **Frequency Response**—uniform from D.C. to 100 cycles per second
- **Voltage Gain**—1000 Approximately (one chart millimeter pen displacement per millivolt signal)
- **Stability**—drift—less than one chart mm. per hour
- **Calibration Circuit**—for convenient determination of input signal levels
- **Centering Control**—to position pen electrically to any point on chart
- **Power Requirements**—115 volts, 60 cycles
- **Portability**—Weight 30 pounds

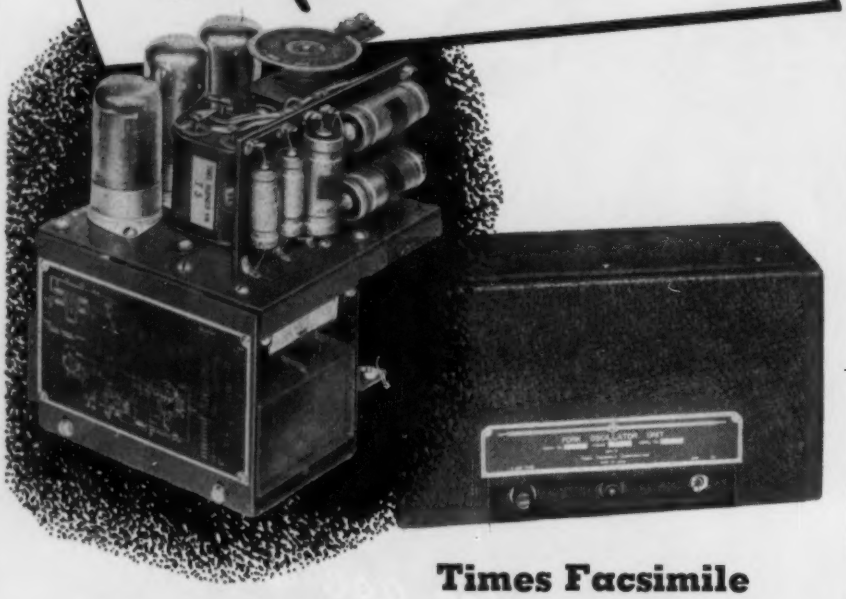
a product of

The Brush Development Co.

3419 Perkins Ave., Cleveland 14, Ohio

Canadian Representatives: A. C. Wickman, (Canada) Ltd., P. O. Box 9, Station N, Toronto 14

Here's Laboratory Precision in a portable unit . . .



Times Facsimile

CONSTANT FREQUENCY AUDIO OSCILLATOR

Frequency Maintained To Within One Part In Five Million Per Degree Centigrade

Here's a Frequency Oscillator designed and engineered by Times Facsimile Corporation with laboratory precision—rugged, compact, portable.

Times Facsimile manufactures oscillator units for any specified frequency between 60 and 4,000 cps.

The Oscillator is available as a separate unit, or complete with power supply in cabinet, or relay rack mounted—price range $300—$500.

Times Facsimile Corporation is one of the world's leading manufacturers of facsimile equipment. Write today for catalogs describing facsimile equipment and components.

TIMES FACSIMILE CORPORATION

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The New York Times Company

229 West 43rd Street New York 18, N. Y.

tection relay detects faults in generat or generator leads and clears syste before damage occurs.—*Aviation Di Westinghouse Electric Corp., Lim Ohio.*

Please mention number 432 when filling out card

Pneumatic Tool for Solderless Wire Terminals

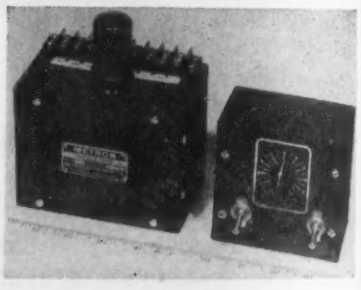
New pneumatic-powered hand to installs solderless electrical termina with the speed and precision of a pow press, makes completed connections

fast as operator can insert wire an pull trigger, is made for wire size from 22 to 14, uses 85 lbs./in.^{2} pres sure.—*Aircraft-Marine Products Inc. 1568 N. Fourth St., Harrisburg, Penna*

Please mention number 433 when filling out card

Welding Timers

New welding and industrial timer are said to permit highly versatile ap plication. They are exceptionally small control box is 4" × 4" × 2", can b

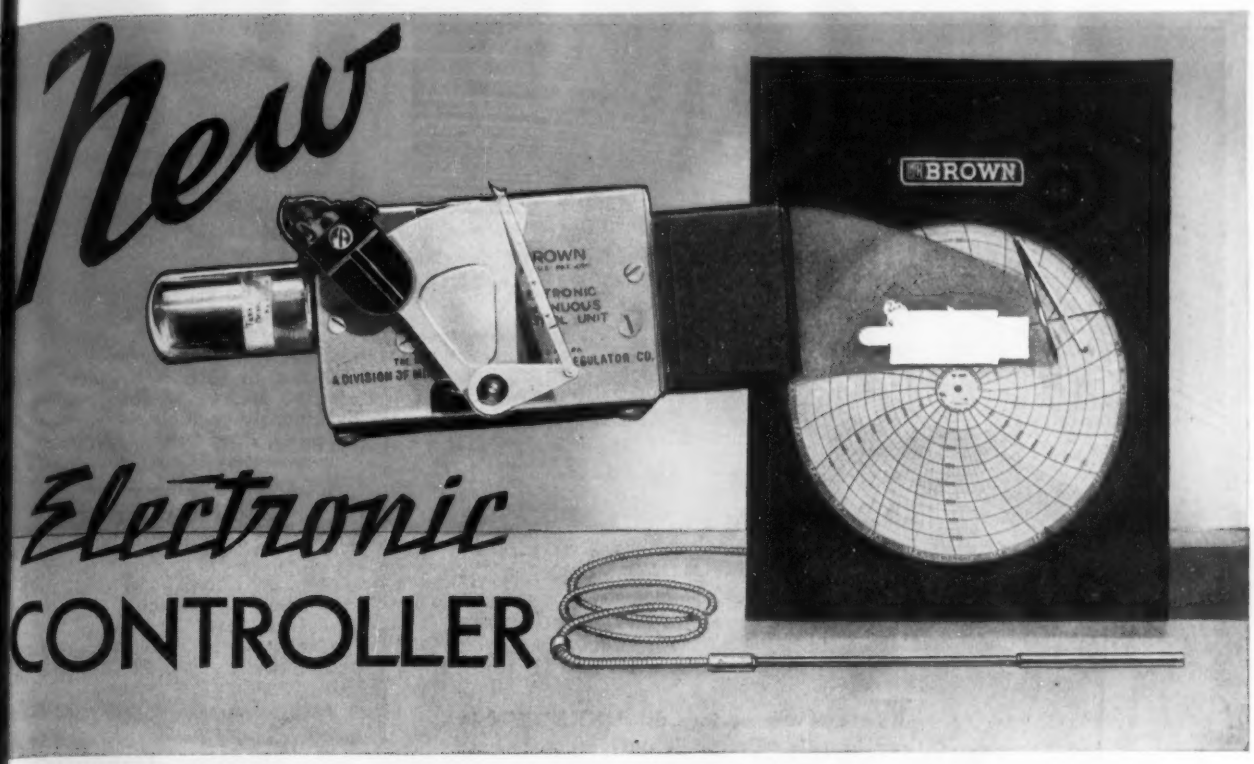


mounted with bracket or incorporated in machine near operator, with timer box out of the way. Or, control box ca be screwed to timer box for mounting as an integral unit. Timer is electronic: one tube and two relays. Timing intervals from 1/60 second up to several minutes can be provided in one or several continuously-variable ranges. Also available: (1) adjustability by steps; (2) fixed-interval timers.—*Metron Instrument Co., 433 Lincoln St., Denver, 9, Colo.*

Please mention number 434 when filling out card

30-kc. to 30-Mc. Oscillator

New "Model No. 2 Mega-Sweep Oscillator" incorporates several new features: Carrier frequency may be in-



FOR TEMPERATURES AND PRESSURES

This is the new Brown *Electr-o-Vane* Control Unit. To users of electric contact control Thermometers and Pressure Gauges, it offers a high degree of control performance never before attained.

A true triumph in control, this electronic unit is not merely an adaptation of a known principle but an achievement in design by which all the shortcomings of similar devices are eliminated.

Added to the Brown Thermometer and Pressure Gauge line, the *Electr-o-Vane* Unit provides a control instrument of unequalled performance. No instrument of this type can equal its dependability in service, its precision in operation or its safety features.

Brown *Electr-o-Vane* Thermometers and Pressure Gauge Controllers are available *at no premium cost*. With all the exclusive features of these instruments, why compromise with less than the best.

The NEW CATALOG fully describes the operating principle, features and models of the Brown *Electr-o-Vane* Controller. A copy will be sent to you without obligation. Write today for Catalog 6001.

THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Company*, 4482 Wayne Avenue, Philadelphia 44, Pa. Offices in principal U. S. cities and in Toronto, Canada; London, England; Stockholm, Sweden; Amsterdam, Holland.

HERE ARE THE FACTS

The Brown *Electr-o-Vane* Control unit operates on the principle that when a metal vane is interposed between two oscillator coils, the state of oscillation can be made to change or stop in an electronic circuit. This change or stopping of oscillation causes the electronic circuit to operate a load relay.

The oscillator coils are the heart of the controller. Brown oscillator coils are molded in bakelite and are thus *moisture-proof*—an exclusive Brown feature. A knife-edge control action is provided that does not drift. Control action is precise. It never varies. It is unaffected by moisture conditions.

Only the circuit used in the Brown *Electr-o-Vane* Control Unit causes an actual stop in oscillations. That is why this is the only instrument of its type providing real *snap action*—an important factor for precision control.

Brown *Electr-o-Vane* Control is contained in a neat, compact unit. It is self-contained, easily removed as a unit and unaffected by dust or dirt.

Electr-O-Vane

THERMOMETER CONTROLLERS

PRESSURE GAUGE CONTROLLERS

Beyond...

...“the great undiscovered ocean of truth”...

We can venture into the UNKNOWN in any branch of research only as fast as we can MEASURE each new conquest.

New Hathaway instruments are being developed and standard designs are being constantly improved to keep abreast of the expanding demands of modern research.

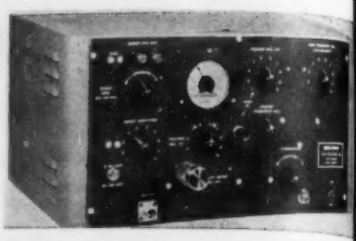
Whatever your requirements may be in special instruments for measurement or control let Hathaway instrument engineers help you.

Hathaway Type S8-B 12-element oscillograph—one of a complete line of recording oscillographs

You can rest assured that you will find in any Hathaway instrument the *most advanced design*, and the *most exacting craftsmanship*.

WRITE FOR TECHNICAL BULLETIN SP-165B

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO



creased to 1000 Mc. to cover color te vision bands. Low amplitude modu tion while sweeping is now less th 0.1db per megacycle. An improv wave-meter provides metering fr 1000 Mc. to 1Mc. Frequency sweep from 30 Mc. to 30 Kc. Attenuator continuously-variable. — *Kay Elect Company, East Orange, N. J.*

Please mention number 435 when filling out card

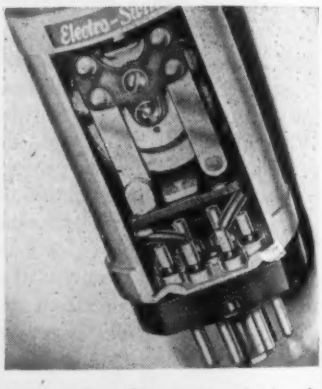
Mercury Switch

New “Model AS-408D” mercu switch is less than 1½” long, is s-p.s is rated at 1 amp., 115 volts, a-c., w save space in switch action mech isms, is actuated by a snap tilt of 1 —*Minneapolis-Honeywell Regulator C 2727 Fourth Ave., S. Minneapol Minn.*

Please mention number 436 when filling out card

Hermetic Terminals

New Fusite Hollow-tube Multi Hermetic Terminals are shown in u in this photograph illustrating a plu

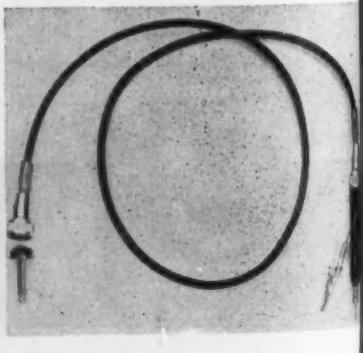


in type of relay manufactured Electro-Switch and Controls Co *Cincinnati Electric Products Co., Car age St., at Hannaford, Norwood, C cinnati 12, Ohio.*

Please mention number 437 when filling out card

Rectifying Probe for Circuit Testers

New “Type MI-8263” miniature cr tal rectifying probe adapts RCA “Vo Ohmyst” and “Chanalyst” for circ



Lifting a Product's Value Two Ways ...automatically!

When an eastern woolen mill operator doubled production and increased wool tensile strength 17% by installing Bristol's Coordinated Control System to his Hussong Dye Vats, his better product cost less.

OTHER PROVED ECONOMIES

A western milling company reports greater uniformity in flour with less operating cost since a Bristol Recording Ammeter started pointing the finger at power consumption. And a tire manufacturer gets tires as alike as peas in a pod — with absolutely no rejects due to improper process timing — since a Bristol Cycle Controller stepped into the driver's seat. Many other cases in our files from a variety of industries show similar value-boosting results.

Makes the Everyday Things of Life Cost Less

DOES YOUR PROCESS INVOLVE MECHANICAL OPERATIONS?

If your process now depends on manual control of temperature, pressure, vacuum, liquid level, flow, humidity, and pH value, individually or in any combination, Bristol Instruments and Engineering can make your product better at lower unit cost . . . by putting automatic control in charge. Presenting the facts to top management may get results — *soon*. In the meanwhile, keep up to the minute on process control by writing for literature, specifying your process and problem. THE BRISTOL CO., 113 Bristol Rd., Waterbury 91, Conn. (The Bristol Co. of Canada, Ltd., Toronto, Ont., Bristol's Instrument Co., Ltd., London N. W. 10, England.)

TYPE B HIGH PRECISION POTENTIOMETER

This general purpose potentiometer, incorporating a number of notable refinements in potentiometer design, is widely used for precise temperature measurements including thermocouple standardization, for meter calibration, for checking portable potentiometers and for other critical measurements of DC potentials requiring exceptionally high accuracy. Distinctive features include:

1. Three ranges: 0 to 1.6 volts, 0 to 160 millivolts and 0 to 16 millivolts.
2. Three reading dials—effective scale length of approximately 175 feet for each range. Readings easily estimated to within one part in 100,000 of full-scale ranges.
3. Subpanel switch and slidewire construction for protection of contacts from dust and corrosive fumes.
4. Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
5. Exceptional convenience in reading and adjustment.
6. Solid and substantial construction for many years of trouble-free service.

PORTABLE PRECISION POTENTIOMETER
A two-dial instrument with built-in standard cell, galvanometer and battery, available in a variety of ranges for laboratory, plant and field applications. Described in Bulletins 270 and 270A.

Thoroughly proven by practical application in exacting research investigations for nearly fifteen years. Described in Bulletin 270.

Rubicon galvanometers suitable for use with the Type B Potentiometer are described in Bulletin 320.

OTHER RUBICON INSTRUMENTS

Galvanometers • Resistance Standards • Wheatstone, Kelvin and Mueller bridges • Evelyn Photoelectric Colorimeter for precise chemical analysis • Automatic Recording Photometric Analyzers for NO and H_2S • Magnetic Permeameters • Shorted-turn Coil Testers • Other equipment involving precise measurement of electrical quantities.

RUBICON COMPANY

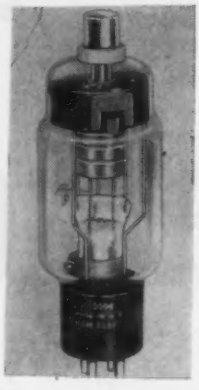
Electrical Instrument Makers

3755 Ridge Avenue • Philadelphia 32, Pa.

testing of television, FM and other VHF applications within the sensitivity ranges of these instruments. It employs a germanium crystal to rectify applied a-c. voltages which are then measured by d-c. circuit of tester: reading is proportional to positive peak of applied a-c. voltage. Excellent linearity is said to be obtained with new probe even at ends of scale.—*Test and Measuring Section, RCA Engineering Products Dep't, Radio Corp. of America, Camden, N. J.*

Please mention number 438 when filling out card

Xenon Rectifier



New "Type 5594" is a xenon-filled thyratron which operates through an ambient temperature range from —55°C. to 90°C. Maximum ratings: peak forward anode voltage: 2500 volts; peak inverse anode voltage: 5000 volts; average anode current: 0.5 amp.; peak anode current: 2.5 amp.; filament voltage: 2.5 volts; filament current: 5.0 amp. — *Chatham Electronics, 475 Washington St., Newark 2, N. J.*

Please mention number 439 when filling out card

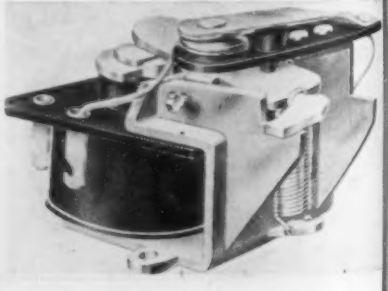
Grid-controlled Rectifier

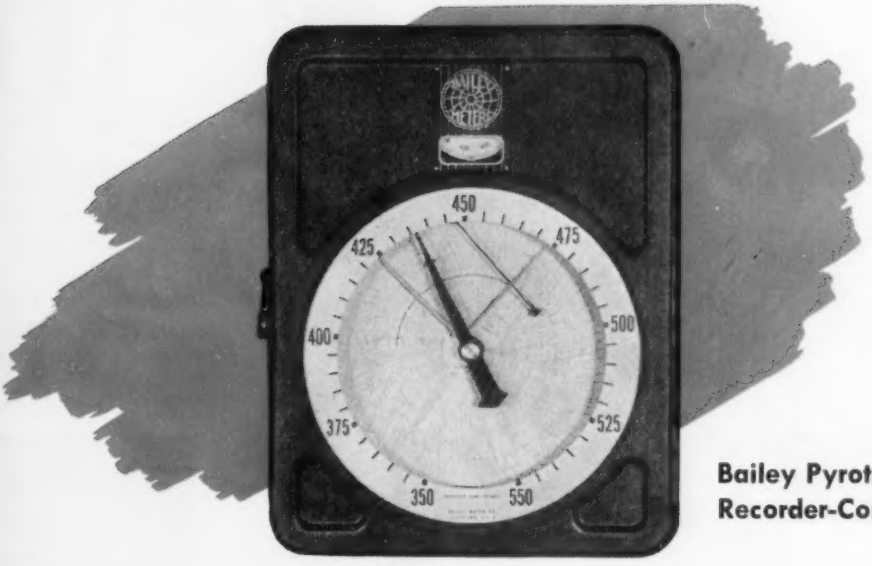
New "Type EL C1J" grid-controlled xenon-filled rectifier tube is said to be ideal for control of a power circuit from a low-energy circuit where either high-speed response or delicate variation of output power is required. Recommended applications: precise motor speed control, servo amplifiers, high-speed or synchronous switching circuits, and high-speed counting or inspection circuits. Principal characteristics: average anode current, 1.0 amps.; peak anode current, 8.0 amps.; max. peak inverse voltage, 700 volts; average arc drop, 8 volts; filament voltage, 2.5 volts; filament heating time, 40 sec. New tube is 4½" long over-all; is "temperature free." *Electrons, Inc., 127 Sussex Ave., Newark 4, N. J.*

Please mention number 440 when filling out card

Motor-starting Relay

New "Bulletin 109 Relay" is designed specifically for use with single phase a-c capacitor motors for oil burners, refrigerators, etc. Operational difficulties inherent with centrifugal switches are said to be eliminated. External or remote mounting of relay is permissible. Relay is a potential





Bailey Pyrotron Recorder-Controller

Looking for Better Temperature Instruments?

...Then check these features of Pyrotron Electronic Resistance Thermometers...

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the Bureau of Standards in establishing basic standards for temperatures from —190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

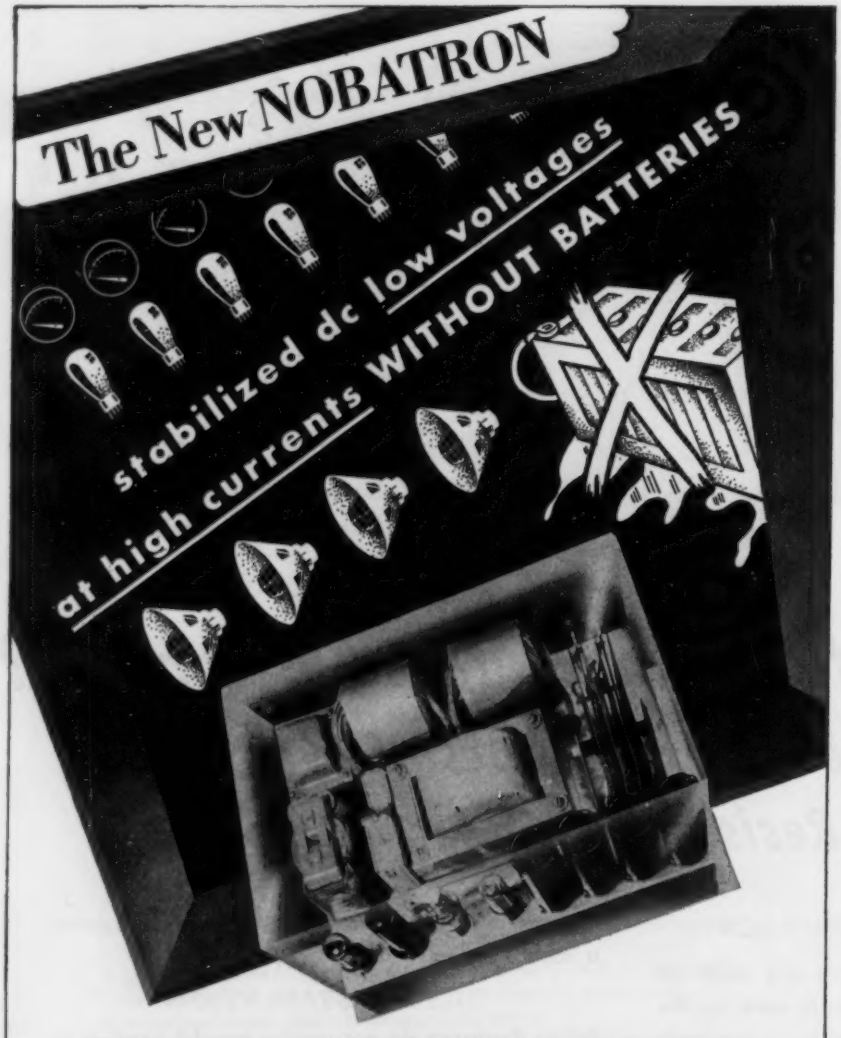
For the full story on this unusual electronic resistance thermometer which is suitable for ranges between —100°F and 1200°F, ask for Bulletin No. 230-A. P-9

BAILEY METER COMPANY

1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO

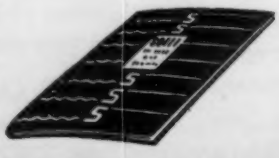
Controls for Processing

TEMPERATURE FLOW
PRESSURE LEVEL
% OXYGEN DENSITY
% COMBUSTIBLES RATIO



- **The Sorensen NOBATRON provides a new source of DC voltages regulated at currents previously available only with batteries.**
- **Six standard NOBATRON models operate on a 95-125 volt AC source of 50 to 60 cycles and provide currents of 5, 10, and 15 amperes at output voltages of 6, 12, or 28.**
- **Ideally suited for critical applications where constant DC voltages and high currents are required, the NOBATRON maintains a regulation accuracy of ½ of 1%, RMS of 1% and has a recovery time of 1/5 of a second.**

● *Investigate the many advantages of Sorensen regulators applied to your unit. Write today for your copy of the new complete Sorensen catalog, S-I. It is filled with schematic drawings, performance curves, photos, and contains in detail, "Principles of Operations."*



SORENSEN & COMPANY, INC.
STAMFORD, CONNECTICUT

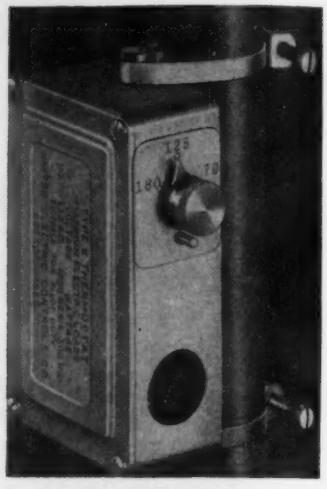
A LINE OF STANDARD REGULATORS FOR LOAD RANGES UP TO 30 KVA.
SPECIAL UNITS DESIGNED TO FIT YOUR UNUSUAL APPLICATIONS.

device operating over a wide range of voltages as distinguished from close differential-current type relay. Chatterless relay operation down to drop-out point is obtained through magnetic circuit design. Contacts are single-pole normally-closed suitable for load as large as a 1 h.p., 115- or 230-volt, 60-cycle capacitor motor. Dimensions: 1½" high × 1¾" wide × 1-15/16" long. —*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Please mention number 441 when filling out card

Strap-on Thermostat

New "Type S" strap-on thermostat is designed for controlling water, steam, chemical, etc. temperatures within a differential of 15°F. between 40°F. and

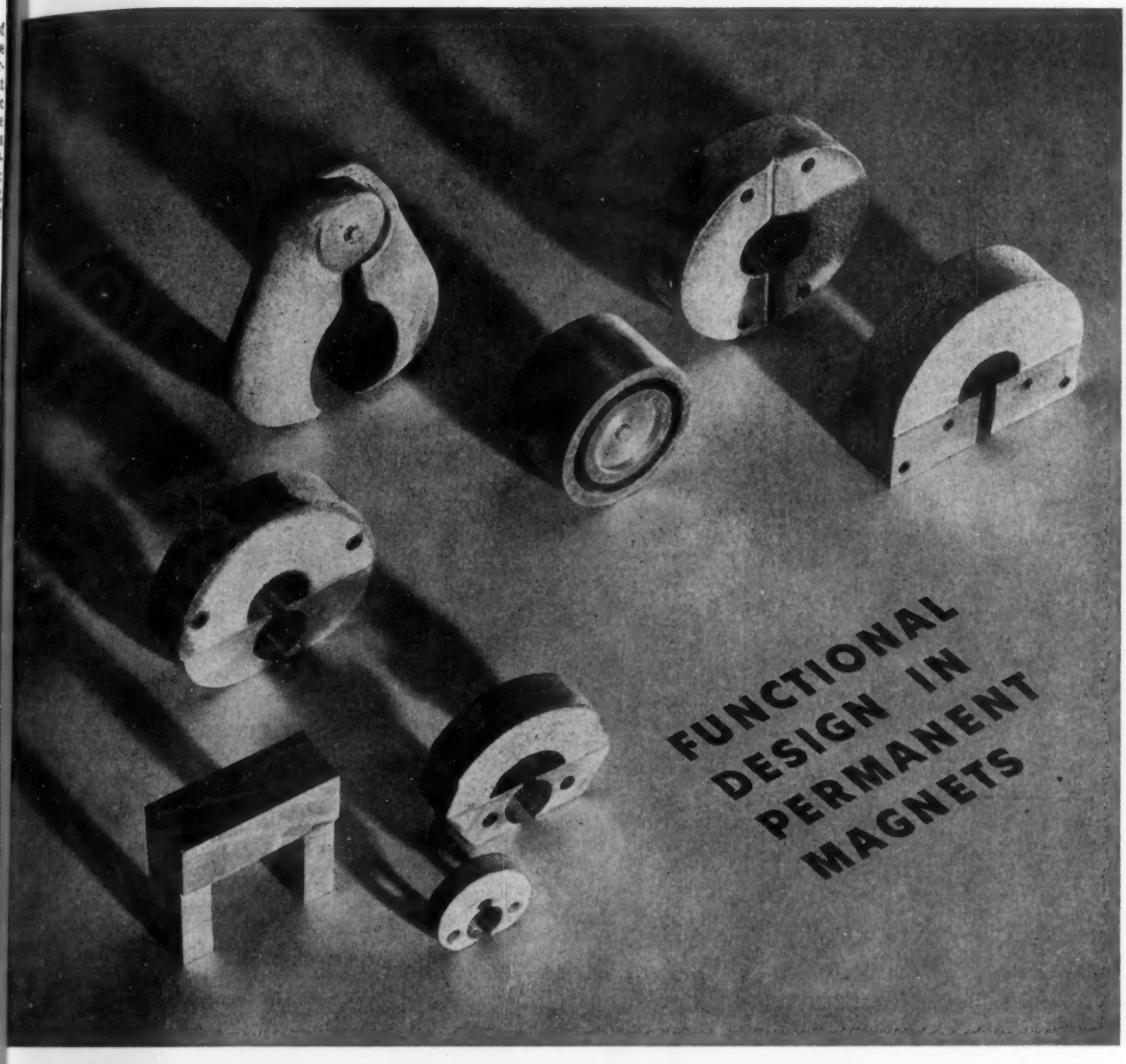


210°F. Bimetal assembly is actuated by heat transferred by rear of thermostat housing. Voltage rating is 110 to 220 a-c.; wattage is 1200 for resistive load, 300 inductive. Switching action available: (1) normally closed, makes on falling temperature; (2) normally open, breaks on falling temperature; (3) double throw, one side normally closed, one side normally open, no neutral position.—*United Electric Controls Co., 69-71 A Street, Boston 27, Mass.*

Please mention number 442 when filling out card

Air Velocity Indicator

New "Air Meter," said to be ultrasensitive, utilizes a combination of the hot-wire and thermopile principles. This arrangement minimizes errors due



The efficiency of every instrument or device in which a permanent magnet is used depends upon the functioning of the magnet itself. *Functional designing* on soundly engineered principles is important in the production of permanent magnets for better, more efficient and economical performance.

The permanent magnet assemblies, shown above, serve both electrical and mechanical requirements. Those designed for the precise operation of test meters must maintain a constant energy source with the magnetic field. Extreme care must be taken in the shaping of these magnets for the desired effect.

Other magnets in which the holding power is the main objective are so constructed that the magnetic circuit permits a far greater applied energy than the magnets themselves can supply. Further applications in which the magnet through its attraction and repulsion acts on other moving parts of an assembly require different design techniques.

The development of new magnetic materials—*Alnico, Cunico, Cunife, Vectolite* and *Silmanal*—has enabled our engineers to adapt permanent magnets to many uses which were formerly impractical.

The Indiana Steel Products Company welcomes the opportunity to help you solve your magnet problems with "Packaged Energy".

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PRODUCERS OF "PACKAGED ENERGY"

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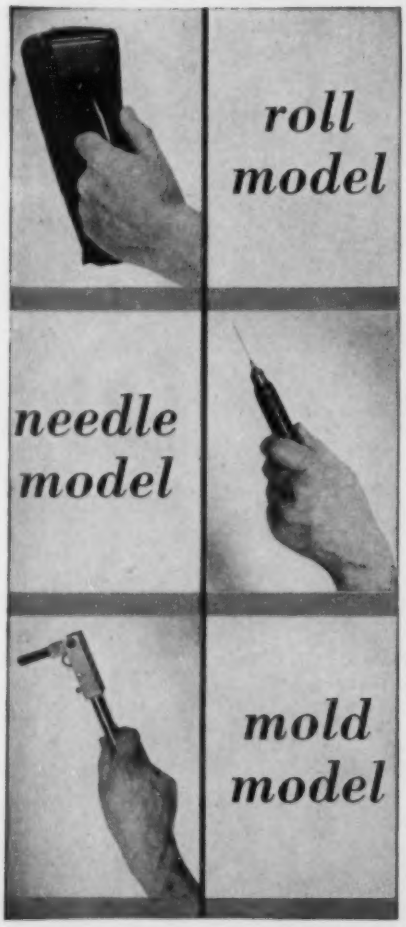
ISP

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN. (CINAUDAGRAPH DIV.)

SURFACE PYROMETERS
for every purpose



● The routine use of CAMBRIDGE Surface Pyrometers takes the guesswork out of surface temperature determination in the plants and laboratories of many industries. The CAMBRIDGE is accurate, dependable, rugged, quick-acting and easy to use. The Roll Model is for checking surface temperature of still or moving rolls. The Needle Model is for insertion into materials in a plastic or semiplastic state for within-the-mass temperature determination. The Mold Model is for checking surface temperature of mold cavities and surface of almost any contour.

Write for Bulletin 194-SA

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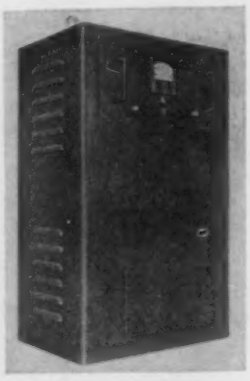
pH Meters, Indicators, Recorders • Gas Analysers • Moisture Indicators and Recorders • Galvanometers • Fabric Permeameters and many other electrical and mechanical instruments. Send us details of your instrument problem for our recommendation.

to air temperature variations. Pick-up, placed in air stream, is a noble-metal thermopile heated by a.c. and with alternate junctions cooled. Temperature rise of warmer junctions is measured by the d-c. thermoelectric emf. genreted. Instrument operates on 110-volt a-c. obtained either from house wiring or from a portable battery-operated power pack. Instrument may be adapted for remote indication; output is suitable for operating electrical recording instruments. Standard range, 0 to 2000 feet per minute. 50 fpm. is approx. 20% of full scale. Velocities as low as 5 fpm. can be measured.—*Hastings Instrument Co., Inc., P. O. Box 1275, Hampton, Va.*

Please mention number 443 when filling out card

Automatic Voltage Regulators

New "Type EM" (electro-mechanical) "Stabiline" automatic voltage regulators incorporate new electronic



and mechanical developments. New control of circuit is said to offer faster detection of line voltage variations, nonmicrophonic performance, ease of installation and servicing, elimination of possibility of damage from shock, compactness, and reliability. All removable components (such as new voltage-sensitive element and new fast-acting relays) are plug-in type. In event of damage to control unit, an exchange arrangement permits assembly to be un-plugged from power elements and replaced by another unit. All wiring is concealed; no exposed live parts—*The Superior Electric Co., 1030 Church St., Bristol, Conn.*

Please mention number 444 when filling out card

Pasteurizing Timer

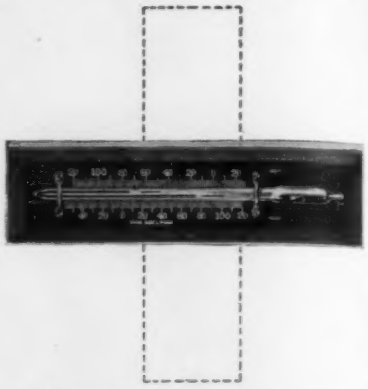
New "Dynalog HT-ST Electronic Timer" is especially designed for high temperature-short time pasteurizing; measures actual time in which milk

travels through holding tube, and actual temperature of milk during that time. Its record is a bold line on a specially-designed chart which has a total scale-range of 155-170°F.—*The Foxboro Co., Foxboro, Mass.*

Please mention number 445 when filling out card

Maximum and Minimum Registering Thermometer

New maximum and minimum registering thermometer is said to have many advantages over conventional type with U tube construction. No magnet is re-

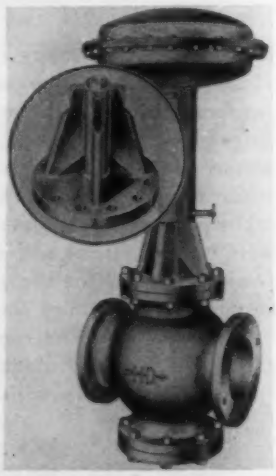


quired: new instrument has one rugged tube with double bore and one bulb, and is used in horizontal position; scale is attached to wood back by means of a swivel ratchet, which is used to turn scale to vertical position (see dotted lines) so that indexes slide back to top of mercury column, thereby resetting instrument. Size, 8½"×2". Scale range, −30 to + 120°F.—*The Philadelphia Thermometer Co., Sixth and Cayuga Sts., Philadelphia 40, Penna.*

Please mention number 446 when filling out card

Vertical Fins for Control Valves

New vertical "U" type fin radiation bonnet is announced for company's diaphragm control valves in sizes 2"



and larger. With valve installed in normal vertical position, "U" section permits a natural draft in addition to radiation. To illustrate: with a common temperature of 1000°F. on body side of bonnet, vertical fins will reduce temperature to 235°F. at packing box, while horizontal fins will permit a temperature of around 360°F. This

"THE HANDIEST TESTING INSTRUMENT WE'VE EVER HAD"

say hundreds of users

MEASURES BOTH

VOLTS AND AMPERES

(ACCURACY 3%)

G-E HOOK-ON VOLT-AMMETER

You get double value from this handy, portable, a-c instrument. It will measure up to 600 volts and up to 600 amps. Just hook it around the conductor, push to close the gap, and read the current. Leads are provided for voltage measurements. Booklet GEA-2950 gives complete details, prices, and many helpful suggestions for operating this versatile instrument. Ask your G-E Apparatus Distributor. ***General Electric Company, Schenectady 5, New York.***

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602-94-6200

BRADLEY

COPPER OXIDE RECTIFIERS

NEW "COPROX" RECTIFIER FOR PORTABLE RADIOS

Small, light-weight but rugged is the new copper-oxide rectifier developed by Bradley especially for portable radio low voltage battery charging.

Rated at 1.5 amperes continuous current, this newest addition to the Bradley "Coprox" line offers a permanent, trouble-free, full wave rectifier. Priced for production use, its small size and versatile mounting provisions adapt it to limited space requirements.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St: New Haven 10, Conn.

greater dissipation of heat from packing box section is said to be obtained regardless of whether valve is mounted vertically or horizontally, owing to larger effective area. When new vertical "U" fin radiation bonnet is applied to stainless steel or alloy valves, a stainless steel tube and disk of specified type is retained by a carbon steel housing. Thus all parts of valve wetted by the fluid are provided in the specified material.—*Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.*

Please mention number 447 when filling out card

Four-range Comparator Gage

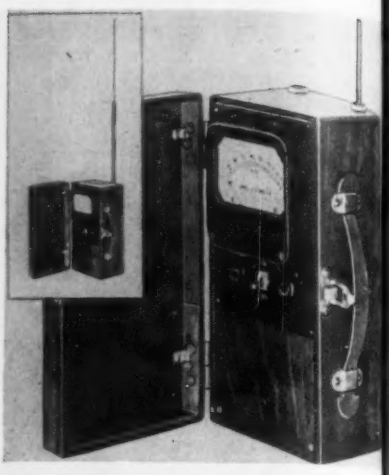
New "Metron Comparator Gage" is of electromagnetic type, does not use any vacuum tubes or other limited-life components, has only two moving parts: spindle (supported in flexure) and the

pointer (mounted on jewel pivots) so that millions of gaging operations and years of service without maintenance are said to be assured. Each gage has four switch-selected magnifications so that it is suitable for a wide range of gaging applications from checking gage blocks to production inspection of machined parts. Three models are available calibrated in either English or metric units: "Model 10" has a gaging range from 1 microinch to 4 ten-thousandths of an inch; "Model 20" has a range from 10 microinches to 5 thousandths; Model 30 has a range from half a ten-thousandth to 20 thousandths. Spindle pressure is adjustable from 4 oz. to 2½ lbs. Head can be rotated at any angle about column or in vertical plane, can be removed for special set-ups. Accessories available include large anvils, stops, flat tips, overhang supports, V anvils, etc.—*Metron Instrument Co., 436 Lincoln St., Denver 9, Colo.*

Please mention number 448 when filling out card

Static-electricity Indicator

New "Statometer" is a portable, self-contained electrical instrument designed to aid in study of electrostatic conditions. It is claimed that this instrument, calibrated in terms of static volts, detects fractional-volt static charges, either negative or positive. Provided with a 2-position scale range switch, it measures any voltage from 0 to 750 volts. There are two sockets on top of the instrument in which an air terminal is inserted, one socket for

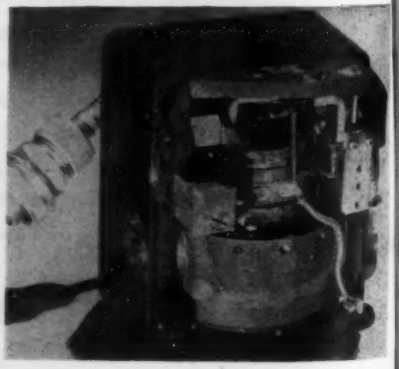


detecting a negative charge and the other for detecting a positive charge. Operation: range switch is turned to low-range position and balanced to zero. As operator approaches a body charged with static electricity, pointer will start to fluctuate. Range switch is then turned to high-range position and as operator comes closer to charged body, pointer will move up-scale. Instrument weighs 5 lbs. 10 oz., measures 10¾" × 4¾" × 6".—*Davis Emergency Equipment Co., Inc., 80 Halleck St., Newark 4, N. J.*

Please mention number 449 when filling out card

D-c. Rate Gyro

New d-c. rate gyro, originally developed for wartime computing gunsights, is an angular-rate-measuring device for use as primary element of control systems. Applications include guided-missile control; stabilization systems (automatic pilots, speed control for machines such as turret lathes); computing systems (providing angular velocity parameter for any complex physical problem); and certain types of angular velocity indicators and accelerometers. Take-off element is of a-c. reluctance type operating at 115 volts, 400 cycles, with output sensitivity of 0.49 volts deg.$^{-1}$ sec.$^{-1}$ and motor element of d-c. governor-controlled, shunt type, operating on a voltage range of 24 to 32. Motor speed is governor-controlled to ±1% over ambient temperature range of −65° to 160°F. in order to maintain accuracy of precession. Operating input currents are low: d-c. 0.3 amp, and a-c. 0.02 amp. Gyro precession is limited to one plane of freedom and is restrained by a carefully-balanced rate spring system. Undue oscillations are magnetically



Can you use a Frequency Standard accurate to One Part in 100,000,000?

The new Western Electric Primary Frequency Standard for 100 kc operation—accurate to one part in 100,000,000—fills every need for a precise frequency source. It's rugged in construction, small in size and weighs only 90 pounds. It is designed for fixed or semi-portable service wherever time-frequency measurements or the synchronous operation of two or more independent systems is required.

Developed by Bell Telephone Laboratories, the new Frequency Standard was used during the war as a Loran frequency source of the utmost accuracy. Rugged enough to withstand hard use, the Standard maintains a frequency accurate to *one part per 10^8 per day* irrespective of moderate changes in ambient temperature, humidity, and air pressure. Actual tests in a Government laboratory have shown a frequency variation of less than *1.4 parts per 10^9 per day.*

For literature or further details, call your nearest Graybar representative, or write to Graybar Electric Company, 420 Lexington Avenue, New York 17, N. Y.

Western Electric

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- FIVE BASIC MOVEMENTS—Electrodynamometer, moving iron, moving coil, thermocouple and rectifier types.
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- SPECIAL FEATURES TO ORDER—Rear illumination, special dials and other features available on most models.

Triplett
ELECTRICAL INSTRUMENT CO.
BLUFFTON, OHIO

damped.—*Fairchild Camera and Instrument Corp. 88-06 Van Wyck Blvd., Jamaica 1, N. Y.*

Please mention number 450 when filling out card

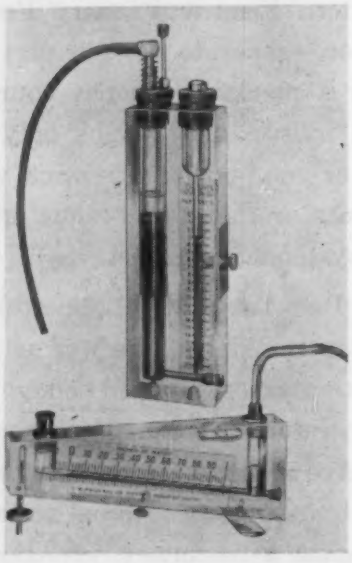
Volume Control for Metering Pumps

New "Micro-indicating Stroke Adjustment" for regulating, while running, volume of liquid pumped by maker's Chemical Pumps has a vernier dial which permits resetting to within 1/750 of full stroke without stopping pump. Maker's pumps are available also with automatic motorized stroke adjustment.—*Milton Roy Co., 1309 E. Mermaid Ave., Philadelphia 18, Pa.*

Please mention number 451 when filling out card

Combustion-test Instruments

New line of combustion testing instruments includes portable and stationary transparent CO_2 Indicators, Draft Gages, Manometers and accessories. "Model 800 Transparent CO_2 Indicator" is said to be of such simple

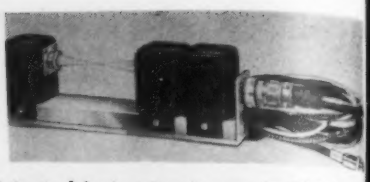


design that even an inexperienced operator can make accurate tests with little or no training. Body is a clear plastic unaffected by bright red indicating solution; all metal parts are stainless steel; instrument is said to be virtually unbreakable. "Model 100 The Portable Draft Gage," also of transparent plastic, has 5" scale with more than an inch of sliding adjustment.—*F. W. Dwyer Mfg. Co., 317 South Western Ave., Chicago 12, Illinois.*

Please mention number 452 when filling out card

High-resolution Photoelectric Pick-up for Electronic Counter

New "Model 600 Photoelectric Actuator" is of high-resolution type for counting pills, watch screws, etc. It has a beam approx. 1/16" wide and will respond to changes in light level as small as 20%. Complete interruption of light beam not being required, objects as small as 0.001", and objects which do not have a distinct separation, can be counted. Now unit is designed to

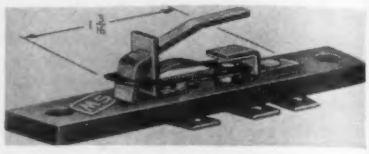


detect objects at rates up to 30,000 per minute, also contains a capacitor discharge output circuit for high-speed operation of control solenoids such as required for deflector gates and packaging equipment.—*Potter Instrument Co., 136-56 Roosevelt Ave., Flushing N. Y.*

Please mention number 453 when filling out card

Unhoused Micro Switches

New "SK Series Micro Precision Switches" are small, unhoused, skeleton-type precision snap-action switches

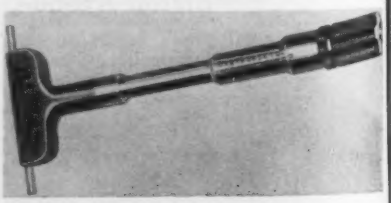


particularly adapted to actuation by rotating or sliding cams. These single switch units are available in normally-open, normally-closed, or double-throw circuit arrangement. Switch element, 1 3/16" long, is mounted on a laminated phenolic base. Where control of several circuits require multiple control by cams, slides, or push buttons, "SK" switches can be ganged or compactly mounted on a common base on centers as close as 7/16". Tentative rating is 10 amps. 125 volts; 10 amps. 250 volts; a-c. Tentative characteristics: operating force, 3 to 8 oz.; release force, 2½ to 7 oz.; movement differential, 0.008" to 0.022"; overtravel, 1/32" min. (1/16" nominal); free position, 0.343" approx.; operating position 0.300" approx.; net weight, 0.01 lb.—*Micro Switch, Freeport, Illinois.*

Please mention number 454 when filling out card

Inside Micrometer

New "Rimat" inside micrometer is said to be a new type giving direct reading, will save time when machining back of a flange or boring recesses: instru-



ment can be inserted, measurement taken, measuring pins retracted and micrometer withdrawn. New micrometers have a range of 1" and are available in two sizes: 3" to 4" size with extra measuring rods up to 6"; and 6" size with extra measuring rods up to 12". Special sizes made on order.—*Richards Machine Tool Co., 124 South Isabel St., Glendale 5, Calif.*

Please mention number 455 when filling out card

EDITORIAL By M. F. BEHAR

Blind Buying Is Gambling

SOME folks like to attend sales of impounded cars, liquidated estates or unclaimed property. This pastime is exciting because of the element of chance, though even churchmen don't call it "gambling." If, among those good folks, there are some who intentionally gamble . . . well, they are private citizens risking their own money.

Uncle Sam is selling hundreds of thousands of different surplus items. All of us wish him success—if only to lighten our future tax burdens. And if some folks buy surplus gadgets sight unseen with their own money, well and good!

The War Assets Administration is advertising surplus industrial instruments in industrial magazines through full-page ads at regular rates. The WAA placed an order for such advertising space in *Instruments*.

This order was turned down.

It was turned down because The Instruments Publishing Company does not like to encourage industrial corporations to gamble and does not like to give the impression that it believes the major assertions and implications in this advertising.

It's not a question of accepting or rejecting "advertisy" statements. Month after month we accept ads asserting that various products are "the best in the world"—or other such expressions. But we HAVE turned down ads—sometimes pending revision, sometimes flatly—when we were morally certain that the great majority of our subscribers would not benefit. In this case we ARE morally certain that the great majority* of our readers would be gambling unwisely if they made blind purchases as a result of this WAA advertising.

This Company's moral certainty is based upon experience and actual case studies. We are not guessing. We can prove our contention:

The rejected full-page ad is headed as follows:

At Last

FULL INSTRUMENT CONTROL

A Plan *Any* Business Can Easily Afford

Note that "*Any*" is italicized. It is not true that any business can afford the "plan" (gamble). Note also that the ad is addressed to businesses rather than to individual gamblers.

The main text reads as follows:

No question that complete instrument control of every step in your process could improve quality and slash production costs. Trouble has been first costs. Good instruments are difficult to make, expensive to purchase. With surplus it's a different story. Thousands of top quality new and used instruments are available now in every WAA Regional Office at prices any business can afford. You can install control and pay most of your installation labor costs out of the price differentials in the equipment. . . .

That good instruments are "expensive to purchase" is the sort of half-truth that poison-pen columnists use: true only in that a 10-lb. instrument costs much more than ten pounds of steel or glass. Industrial instruments are not luxuries but investments: if they did not pay for themselves, YOU, my dear *Instruments* subscriber, and your fellow users, would not buy them to the tune of $500,000,000 a year from a thousand instrument-making companies. As you know, these companies competed fiercely with one another before the war and are again competing fiercely now that their market is not one avid customer but tens of thousands of prudent buyers like you.

Our chief objection to the ad, however, is that it deals with "instrument control of every step in your process" and names "Temperature, Flow, Liquid Level," etc.

Process control instruments are not bought by individual speculators with their own money: they are purchased by companies. Moreover, they are not and cannot be merely "ordered" but they must be carefully SPECIFIED.*

The WAA officials and the advertects who composed this ad shouldn't be blamed: in common with the general public they view process control as oft-photographed control boards gleaming with orderly rows of instruments that look alike; they know little of the FUNCTIONAL DIFFERENCES between instruments that look alike; they don't know that REAL INSTRUMENT ENGINEERING IS BACK-OF-THE-BOARD ENGINEERING.

One of the case studies we mentioned brings out this point. Here are the FACTS, dramatized but unaltered:

Act I.—An engineer in a near-by plant puts in a requisition for a flow controller. The plant Purchasing Agent has just seen the WAA ad, phones the WAA, is told that a flow controller is available and that he can make his own price. Knowing that the requested control system would cost about $800, he offers $200. He gets "the instrument."

Act II.—Engineer phones local representative of instrument company: "We got one of your flow controllers installed but it won't work." Representative rushes a service man.

Act III.—Service man finds a flowmeter instrument (*not* a flow controller, not even a complete flowmeter), mounted on a board: not installed into the process. He can't install it, even as a flowmeter, because the orifice plate and other essentials are missing. Even if these parts were on hand, the instrument would be useless because its range is wrong. Service man reports this to engineer and informs him that the second-hand instrument for which P.A. paid $200 is priced at $150. Exit service man (without leaving a service-call charge slip).

Act IV.—Engineer is "frantic" (wording of case study on our desk) and, after consulting P.A., phones instrument-company rep to find out delivery on a properly-specified flow controller. He is told "ten weeks minimum." He pursuades P.A. to place the order and to obtain the assistance of himself and instrument rep in writing the specs.

Act V.—Engineer and P.A. try to find some use for the bare instrument bought from WAA. They haven't succeeded yet.

Therefore, we suggest a future Act VI in which the engineer and the P.A. would justify the $200 expenditure by writing an article—not for *Instruments* but for all the periodicals accepting the WAA process-control ad. Their company would thus earn more than $200 worth of good-will!

Case Study No. 2. Purchaser of a WAA recording thermometer finds it not quite suitable, phones instrument company rep for a service man. Service man discovers that bulb is wrong, bulb fitting wrong, tubing too short, tubing material wrong and—what makes instrument useless—upper limit of range is 200°F. although process temperature is around 700°F. Purchaser learns that "converting" his "bargain" would cost more than a new instrument.

Case Study No. 3. An educational institution whose Physics and Engineering Schools are both world-famous has a staff member devote his entire time to (1) locating surplus scientific and industrial instruments and (2) inspecting them to determine whether they are usable. A professor told us: "The government sells us these instruments far below cost, but Dr. X seldom finds one which can be used without expensive repairs or reconversions."

The reason we cite this third case is as follows: We had decided to urge the WAA to stop advertising instruments to INDUSTRY and to circularize only the scientific, engineering and technical SCHOOLS, the direct-mail advertising to be free from ballyhoo and to consist of lists of prices, locations, etc. But in order to verify the correctness of our decision we made inquiries among instrument-conscious educators. Now, we do not suggest that the WAA SELL these instruments: we suggest that the WAA GIVE them to educational institutions—especially to schools where veterans being trained at government expense NEED to handle and adjust and otherwise USE instruments.

We most earnestly urge that the WAA stop spending the taxpayers' money on those full-page advertisements of surplus instruments.

Some folks like to bid on impounded cars. . . . "You sure bought y'self a bargain, mister: all she needs is a new engine, transmission, differential, battery, brakes, radiator, carbu—*Ouch!!*"

*If some among the small minority of our readers—individuals using their own money—want to buy used industrial instruments that saw service in war plants, well, it's their own money they're gambling with and we wish the best of luck to them . . . and to Uncle Sam!

*The specifications for one single automatic process control system must cover not only several factors pertaining to (1) the panel-board instrument but numerous factors pertaining to (2) the primary measuring element, (3) the connecting tubings, (4) the control valve or other final element, (5) the power unit, (6) the power supply auxiliaries; and sometimes as many as ten or fifteen other components without which the control system cannot work—without which the process cannot be started on "automatic operation."

Trends in Electric Gaging Methods*

By HOWARD C. ROBERTS, Special Research Associate Professor, Engineering Experiment Station, University of Illinois, Urbana, Illinois

FOR some forty years, electric gaging methods have had consistent, energetic, and rapidly increasing application. Yet, even now, the aggregation of workable techniques which has been developed has hardly earned the right to be called a science—it has not yet been well enough organized nor well enough documented.

There are two principal reasons for this: first, each worker has (usually) produced a specialized method to fit his own need; and, second, many of the methods which have been produced have been no more than offshoots of other electrical developments. The development of electric gaging methods has closely parallelled the development of other electrical devices. One result of this has been that an engineer requiring an electric gaging device has simply surveyed the field, then modified an existing device until it filled his need. It is only recently that engineers have specialized in developing equipment; usually it has been developed by the man who wished to use it—because he had to—and he was much less interested in producing equipment which might later be used by others. There has been virtually no attempt at standardization of methods or of equipment, and not nearly enough analysis of methods.

This situation, which can only be described as unfortunate, can largely be explained by an examination of the history of the art.

The first method, to my own knowledge, devised for the measurement of mechanical magnitudes with electrical devices appeared in 1908. It was a mutual-inductance type extensometer with radio-frequency excitation. This instrument was not widely used; it was in fact foredoomed to failure because of the lack of suitable indicating instruments. But this development is worthy of note, because it was apparently developed to fill a specific need and because the principle has in recent years become quite popular.

The next development to be considered is the Whiddington ultramicrometer, invented in 1918. To the inventor, this was hardly more than an interesting application of the oscillating electron tube, although its value was immediately recognized by a number of people who were in need of sensitive measuring instruments. The principle is still in use but it is probable that, except for its appealing name, Whiddington's specific method would be forgotten. (I do not mean to belittle the accomplishment; Whiddington deserves credit for inaugurating a general method of great utility.) After the original disclosure, Dowling and others developed the device to the point where it became a useful laboratory instrument.

The heterodyne methods now in use are a far cry from the original form; they have grown up with the electron tube.

The next development entering this analysis is the inductive type of primary element, which appeared in both Germany and the United States shortly after Whiddington devised his ultramicrometer. The occasion for the development was, in Germany, the need for a torsiometer; in America the need was for a device to detect deformation of compressor pistons. In each instance a special-purpose device was developed, and in neither instance was the development followed by detailed organized study of the problem or of the full possibilities of the method. Inductive primary elements are still in use; in the last few years many new applications have appeared, and the scope of their abilities has been greatly extended.

The last decade or so has brought a tremendous increase in the popularity of the resistive type of primary element; principally this is because of the large numbers of inexpensive resistive "strain gages" which have been used. These resistive "strain gages" became convenient for general use only after the electron-tube amplifier became a widely-used device. Some resistive primary elements can operate without amplifiers, but many (and among these are the small resistance-strip strain gages which have so increased in popularity since 1937) cannot accommodate enough electric energy to actuate any excepting the most sensitive indicating galvanometers. This, we should note, is another type of primary element which —though known and used for many years—did not achieve wide popularity until convenient auxiliary equipment became available.

Study of the chronological development of the several types of electric gaging methods is of considerable interest because it discloses the reasons for the directions of development and for their extent, but space here does not permit more detailed discussion. It is more pertinent to consider the presently-popular methods. In this treatment, I should say, I shall concern myself as much with their philosophies as with their techniques.

This is perhaps a suitable time for me to point out that since my occupation is civil engineering, I am more actively interested in structural testing than in most other applications of measurement, and that these comments are directed primarily at structural test methods. There are many differences in terminology between structural testing and control and regulator study, but there are many points of resemblance in both technique and philosophy. Here, surely, we should consider similarities rather than differences. Widespread and multi-purpose, instrumentology is the common factor which links together many professions without being a specific part of any one alone.

Our present-day practice employs primary elements of capacitive, inductive, and resistive types principally, but to a smaller extent other types (piezoelectric, photoelectric, and some others) are in use. For most applications these are so applied as to measure displacement directly; that is, their mechanical construction is such as to convert the unknown magnitude into a displacement or a change in dimension, then to convert this change in dimension into a change in an electrical parameter. Acceleration, for example, causes displacement of an elastically-suspended mass; this displacement is then measured with an inductive, capacitive, or resistive element. (Even in the piezoelectric accelerometer a mass is caused to exert a force on a crystal; the potential output of the crystal is proportional to the stress within it.) Force or torque can be made to cause displacement in an elastic member; pressure will displace a diaphragm—again, the magnitude actually measured is displacement. Flow is often measured in term of differential pressures; quantity in terms of the change of level in a container. It requires little effort to demonstrate that a startlingly large proportion of our measuring methods are inferential ones.

If that statement seems to imply that inferential methods are *per se* undesirable ones, let me correct that impression. Some magnitudes can hardly be measured except by inferential methods—stress is an outstanding example of such a one—and for others inferential methods are much more convenient than positive ones.

But in my own line at least, the use of inferential methods has increased tremendously in the last five or six years, and sometimes at the expense of rigorous accuracy. This trend is one to be deplored.

The principal reason for this rapid growth of inferential methods as against direct or positive methods was that military needs required that testing programs be hurried up to the very limit of usable speed. Often this re-

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept., 16-20, 1946.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

quired that an inferential method be used, simply so that existing equipment could be employed without change; occasionally an inferential method was selected because it might shed light on several phases of a problem at one test. Under the circumstances, such a method of attack was very effective—therefore desirable.

But in consequence of this, the practices of testing have changed. The tendency to "follow the path of least resistance" has caused us to multiply our methods without improving them. By that, I mean that we have often used several distinct methods, identical in principle and differing only slightly in technique, for each of the commoner problems. At the same time, and probably because of the existence of these many modifications, there have been few worth-while improvements in basic methods during the war years—although techniques have been refined.

Now, I might divide the development of electric gaging methods into two periods: the slower early growth when new methods were produced partly as by-products of other developments and partly to fit specific and unusual needs; and the period of artificially-accelerated growth during the war years when military necessity forced development into the most effective but not always the most desirable directions. It is surely justifiable to say that up to the present our methods have been more vigorous than rigorous. They have served their purposes; but there are few of us who can doubt that they might be much better.

This meeting, which has been called the "Instrumentation for Tomorrow" Conference, surely is a suitable occasion to consider better methods for the future. It may be, too, a good time to analyze our present methods and philosophies, and perhaps to discard some and to improve upon others. I should like now to describe one impression of our philosophy of testing, and to point out an opportunity or two for future development. These suggestions will be in generalized form, and will express my own opinions only.

There are, I believe, certain basic errors in our present practice—errors of judgement rather than of fact. If they are to be corrected (and some of them, I think, must be) they will be easiest corrected now; not later, after they have been incorporated into more and more pieces of equipment.

One of these errors is the use of inferential methods without, often, realizing that they *are* inferential methods. This has come about, I think, simply because of the physical convenience of the popular commercial forms of primary elements. There is an undoubted temptation to use an existing method if the equipment for it is easily available, and it is not difficult to overlook errors which, though inconspicuous, may be fundamental.

Closely related to this is the looseness of our terminologies. For convenience, most of us use a sort of dialect for discussing our professional subjects, and this dialect can be most misleading if the listener is not familiar with the work as well as with the language. And, when we engage in instruction, this danger becomes greater. An outstanding example of this loose terminology is the common practice of referring to the "measurement of stress" when what is really meant is the "measurement of strain or elongation and the computation of stress." Here we phrase a statement most improperly, entirely for convenience, and ordinarily the listener is not misled. But the usage has an effect, psychologically—we have so grown into the feeling that stress cannot be measured that we make no effort to measure it. Just now, it is true, we have no methods for the direct measurement of stress; yet we could arrive at a closer approximation of actual stress values if we used other methods than those most commonly used.

This leads me to the three points that I wish to emphasize; (1) that for best results in measurement a logical analysis of a problem should always be made; (2) that for most efficient use of time and material a systematic arrangement of equipment is essential, and (3) that we are in sore need of better primary elements.

It is in order for me to provide an illustration of each of these, and I shall do so. For the first, it will be more informative for me to offer a generalized example than a specific one; for the second, a specific example is in order—the one given has a number of obvious deficiencies but will serve as an example. As for the third—there are a few recent developments which I can describe, but principally I can only list some which are not now available but for which a need is clearly indicated.

First, the analysis of a general problem:

When a structure is to be studied, the first problem is of course how measurements are to be made, and of what magnitudes? If equipment is already available, there is a natural temptation to try to use it. But there is a danger that the data which can be secured with the available equipment may not serve satisfactorily the purposes of the test. A desirable method is to consider first the measurements of structural behavior which will best serve the requirements of the mathematical analysis.

Let us state some definitions:

In any determination of the characteristics of a structure, measurements of its behavior are necessary. (Often, although not always, the observed data are employed to formulate a mathematical analysis—the complete description of the behavior of the structure.) In this connection, "behavior" is defined as the entire set of data describing any two conditions of the structure—as the undeformed state and a deformed state. In a mechanical structure—which is anything composed of physically ponderable parts—there will be mechanical, geometrical, and resistive behaviors; together these constitute the entire behavior of the structure. We shall limit this discussion to structures composed of solids.

For the mathematical *analysis* of the structure, relationships must be formulated, or derived, between the magnitudes which are involved in the physical *description* of the structure. Some of these are measurable, and structural testing is the measurement of such magnitudes; the data resulting from such measurements makes it possible (usually, at least) to discover the set of relationships which constitute the mathematical analysis.

A rigorous mathematical analysis will require measurements of a sufficient number of magnitudes to establish these relations; and the nature of the resulting quantities must be appropriate to the form of the mathematical relationships. A rough analogy might be made to the solution of a set of simultaneous equations: you must solve for the proper terms, or you cannot complete the solution. In this sort of investigation, the dangers of inferential methods are obvious.

Basically, a structure can hardly be defined in terms of one behavior only. In any structure, there will be some change in mechanical dimensions, or shape, as the loading is changed. This may be termed the geometric behavior. There will be changes in the distribution of forces or loads; this may be termed the mechanical behavior. And there will necessarily be changes in the internal characteristics of the structure (or of its parts) in accordance with the geometric and mechanical behaviors; this action is hard to name, but for convenience let us call it the resistive behavior. "Resistance" in this context signifies anything which can oppose a force—it may be stress due to elastic or plastic deformation of the material, or it may be the effect of the inertia of the material.

With these concepts, let us consider what can best be measured, but without yet naming a measuring method.

Geometrically, we may measure displacement, rotation, elongation or change of dimension, directly. We can measure the derivatives of these indirectly or by inferential methods. If we wish to measure strain over an infinitesimally short base-length—which we should do if we wish to compute stress at a point or in a plane—we cannot. We must instead measure elongation, or strain over a relatively long base-length, and compute an average value.

As for the mechanical behavior: We can measure forces or loads indirectly, by measuring the deformation of a weighbar. We can sometimes apply known loads. We cannot measure stresses; we can only compute them from other measurements.

The internal characteristics of the structure are often the most interesting

of all; but unfortunately we can make almost no direct measurements of these. We have no means of measuring stress in a structure; we measure strain (for computing stress) indirectly, and other values, such as Poisson's ratio, we can measure only indirectly.

There is clearly a need for close cooperation between the analytical study and the actual measurement. Cannot the analytical study be directed in such a manner as to make the best use of those magnitudes most readily and most accurately measured (such as displacement, change of dimension, or angle) and to require perhaps fewer of those less easily and accurately measured—strain and detrusion, and stress?

Conversely, and for the benefit of the metallurgists as well as the mathematical analysts, cannot we who measure devise methods for exploring the internal characteristics of the structure and of its parts? Can we, for example, make gages for measuring strain over base-lengths comparable to the size of the crystals composing the metal? Can we perhaps employ there an inferential method, making our primary measurement on some magnitude associated with the one in which we are actually interested, but easier to reach?

So far as measuring instruments are concerned, it seems advantageous to the user to establish a rational basis for design of standardized equipment—for general-purpose instruments at least. At the present time, interchangeability of equipment is not common; yet a considerable amount of standardization might profitably be inaugurated.

Let us list the essentials of an electric gaging system:

There must be a primary element, a transmitting, amplifying, or converting system, and an indicating or recording instrument. There must be some source of energy. (Some primary elements are generators, and can operate without amplifiers, thus requiring no external energy source; these, however, are of quite limited application, and are not considered in this classification.) These four elements constitute a complete gaging system; all four must be present.

From the standpoint of practicability—the purely economic standpoint—it obviously is desirable to limit the number of forms of each of these units which must be made available.

For my own uses, I have devised a general-purpose amplifying system which has many advantages. It has become my own "standard"; it was not designed to fit any specific commercially-available primary element, but it will operate with many which are available. Its design is predicated on the supposition that the four elements listed above are all that is required to set up a measuring system. In this system, as a matter of convenience, the source of energy and the transmitting and amplifying system are installed in the same housing.

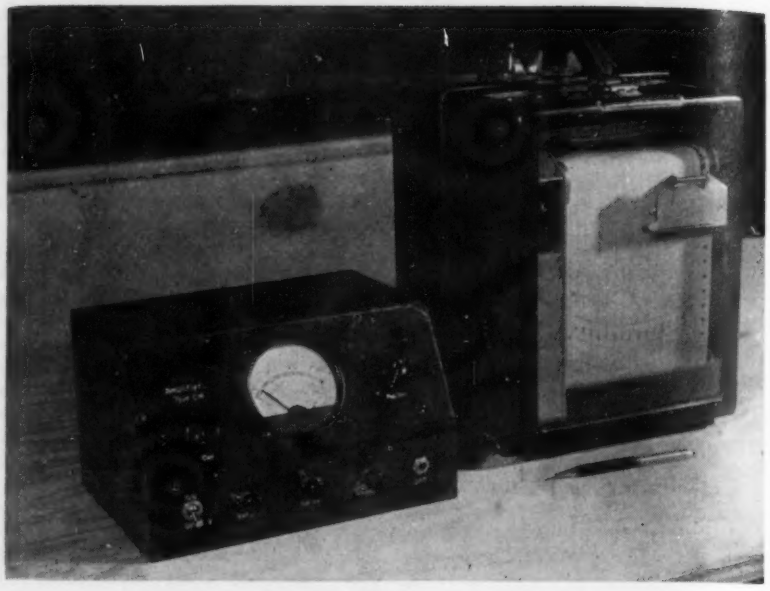


Fig. 1

The intent in designing this amplifier was to provide a unit which can accommodate a wide variety of primary elements, supplying energy for exciting their circuits, and which can actuate any of the three popular indicating or recording devices—pointer-type indicating instruments, low-impedance magnetic oscillographs, or cathode-ray oscillographs. The economic advantages of such an arrangement are obvious: only one sort of electronic instrument is used, with consequent smaller inventories, lower maintenance costs, and fewer complications in use. There is, however, a greater responsibility placed on the selection of the proper primary element, and there may be some limitation in types of measurement possible because of this.

Now let us consider the success of this design:

This amplifier, essentially, is an orthodox resistance-capacitance-coupled electron-tube amplifier. In the same cabinet there is a source of carrier current, of 7,500-cps frequency. There is available (to be connected to the amplifier by operating a switch) a bridge circuit—at least a portion of it—so that either standard commercial resistance-strip strain gages can be used, or variable-inductance gages of approximately the same impedance. The output of the amplifier can be connected to a demodulator-filter circuit which makes available a low-impedance output suitable for pointer-type instruments or magnetic oscillograph galvanometers.

It is possible, by means of another switch, to replace the low-impedance output with a high-impedance demodulator-filter circuit, providing an output suitable for connection to a cathode-ray oscillograph. Or, if desired, the output can be applied directly to a magnetic oscillograph—this gives an amplitude-modulated pattern if a carrier method is used, or makes it possible to operate the equipment as an orthodox resistance-capacitance-coupled amplifier, sensitive to dynamic phenomena but not to static changes.

For some applications, mutual-inductance primary elements are desirable; the necessary alterations in the input circuit to accommodate these are made by the multipoint switch which inserts the appropriate bridge circuit. Some of these require so much carrier energy that an external source of excitation must be used; this may also be handled by the selector switch.

Variable-capacitance primary elements could perhaps be used with this amplifier, but with extremely low efficiency. No effort has been made to provide for their use. Some other interesting forms of operation are possible; it will be easiest to describe them by listing the various forms of primary elements and input circuits which can be used.

The external appearance of the device may be seen in the photograph, Fig. 1. With it is shown a recording milliammeter which has sometimes been used as a recording instrument with this amplifier.

The essentials of an electric gaging system (as listed in an earlier paragraph) are shown in block-diagram form in Fig. 2. At the left is the primary element—indicated here as a resistance bridge circuit; then follow the unit which amplifies the modulated output of this circuit, the rectifier which demodulates it, and the indicating instrument *G*, which may be the recording-type milliammeter of the photograph, or some other form of recording instrument. The power supplies which feed the amplifier and the demodulator (if it is a polarized phase-sensitive device), and which provide the excitation for the bridge circuit, are indicated at the lower part of the diagram.

It is quite possible to employ any

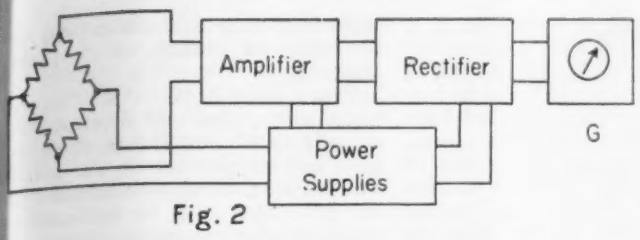


Fig. 2

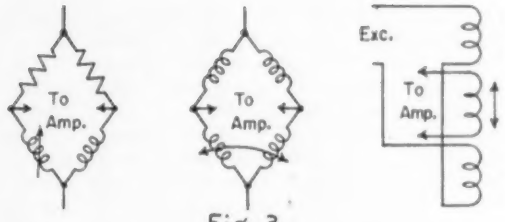


Fig. 3

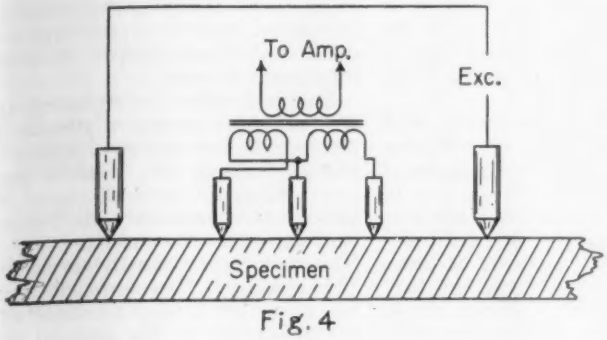


Fig. 4

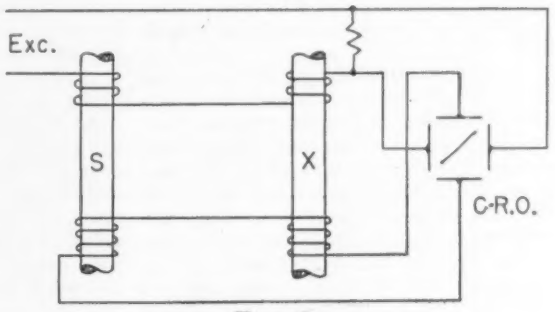


Fig. 5

of several different forms of primary elements with such a system. In Fig. 3 are drawn more of the common types. Where in Fig. 2 a resistance bridge (essentially a Wheatstone bridge) is placed, any of the circuits of Fig. 3 can be substituted. The diagram at the left in this illustration is that for a variable-inductance primary element used in a bridge circuit with two resistance arms and two inductive arms, while the diagram in the center shows an inductance-ratio type of primary element used in a circuit in which all four arms are inductive. At the right is drawn a mutual-inductance primary element, which employs a moving coil in the opposed fields of two fixed coils, so that any motion of the movable coil causes it to link the field of one of the fixed coils more than that of the other and thus to provide an output proportional to the amount of displacement, with a polarity indicating the direction of the displacement.

Almost any of the available forms of primary elements can be used in a manner similar to one or the other of those already shown. The phase-sensitive demodulator can accommodate a signal from any system which may be used. As previously described, it is possible to record a modulated envelope or a demodulated, single-line trace; or for the recording of transients and the like the amplifier can be used with neither modulating bridge nor demodulator.

The system has also been used for exploration for flaws and discontinuities; one type of exploring circuit, somewhat different from the usual primary element, is shown as Fig. 4. An alternating current or an interrupted direct current is applied to the specimen through the outer (larger) electrodes; the resulting potential drop across a portion of the specimen is picked off by the other electrodes. This particular arrangement employs three potential electrodes and connects them so that their output is totalized in the transformer and the difference potential fed to the amplifier. If a flaw should lie between two of the potential electrodes, an output will appear from the amplifier. Although this circuit can be used with several different amplifying arrangements, it is most convenient when used with the carrier-type system and the phase-sensitive demodulator.

Fig. 5 is a diagram of an instrument which may be familiar to many; it is the Siemens and Halske Ferrometer, which some years ago achieved some popularity for the comparison of steels. It employs two exciting coils, around the standard S and the unknown X, so connected as to excite them equally. The exciting current is passed through a resistor, and the potential drop across this resistor is applied to the vertical deflection plates of an oscilloscope. On the horizontal plates is plotted the output of the two similar secondary coils—this is the difference in the magnetic induction of the two pieces. On the screen, then, appears the difference between two hysteresis curves. Typical patterns are shown in Fig. 6. At the left is the straight-line pattern which appears when the two specimens are alike (there is actually a little curvature at the ends, but this is due to amplifier distortion) while at the right is the decidedly distorted pattern produced by unlike specimens. The departure from the straight line indicates the degree of difference and, with some experience, the type of difference may be estimated.

The last figure, Fig. 7, is a diagram of this circuit, modernized—adapted to use with a phase-discriminating amplified circuit. The most powerful methods of this kind employ rather elaborate phase-shifting and combining circuits, but good results may be secured in ordinary cases by using the system directly as a carrier-type amplifier and applying the polarizing voltage to the phase-discriminating circuit in the manner indicated.

This is one attempt at standardizing equipment for one user; it is not a

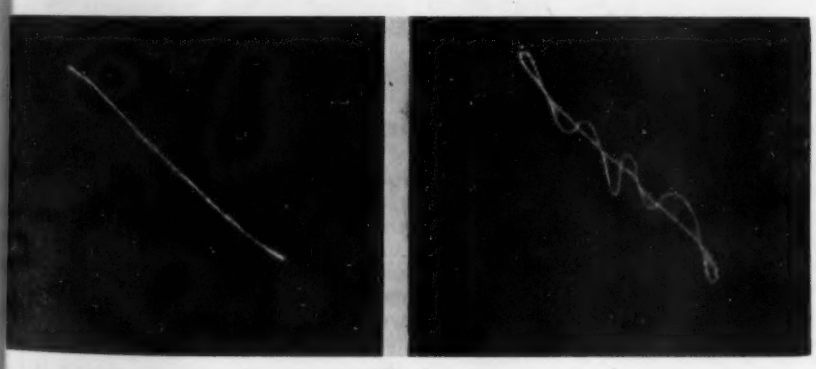


Fig. 6

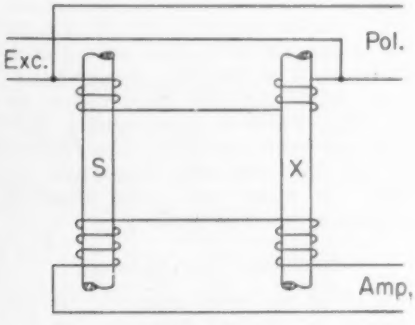


Fig. 7

recommendation for a universal system. It illustrates that some standardization is possible—in this instance a considerable amount of interchangeability is built into one small unit.

As for the last of the three points mentioned—new primary elements—it is not easy to discuss. It is not difficult to say that we need new primary elements to measure things that we cannot now measure, but selection of the proper ones involves many points of difficulty.

One need, certainly, is for gages of shorter base-length. At present, we are just about limited to a millimeter or so, and we do not do this easily. Many tests require that we measure strain in locations where the strain gradient is extremely steep, or in places where the section is changing rapidly. And there is the question of macro-strains versus micro-strains; we must admit that we may sometimes be measuring something other than what we are thinking of.

We need stress gages. There is a device described in the literature for measuring strain in two directions simultaneously, and performing an electrical computation so that the circuit output may represent stress. I have had no occasion to use it; I know little about it. But—whether it is good or bad—its designer recognized the fact that a stress gage was needed; it is therefore a step in the right direction.

We need—and badly—a new type of primary element, one which can be constructed in small dimensions, but have a large output. For pressure measurements, large units can be sources of error. Such a device should be suitable for construction to have any desired modulus of elasticity, so that it can be matched into the material in which it is to be used. And it should be extremely stable; we occasionally wish to bury pressure cells in the ground for years on end.

At this time, I am concerned with the problem of measuring or exploring devices which can examine a material and detect and determine changes in its character. Such a device might conceivably measure stress—it could probably detect stressed portions, at least. We have some such devices, but they are not good enough for our needs. This problem is one of the more difficult ones.

A fresh viewpoint on these things is needed for the production of new primary elements, and it is difficult for those of us who must use our present equipment every day to break away from our everyday methods. Careful logical analysis of problems, like the example given, helps; and it is especially helpful to eliminate as many non-essentials as possible in every such analysis.

There have been in the last few years a very few new developments—entirely novel ones, that is. There have been several revivals of old methods. For example, variable-inductance methods have been used for measurements within mortar and concrete—very small in size, and employing magnetostrictive principles. And there has been a decided revival of interest in mutual-inductance devices.

Non-destructive testing has attracted a considerable amount of attention. Improvements have appeared in sonic and related methods for material inspection; magnetic methods have experienced new modifications. Two novel methods—the Identometer and the Metalsorter—of identifying materials have appeared. These especially interest me, since they involve an attack on the characteristics of the material itself: one employs the thermoelectric property of the metal, the other the triboelectric property. Thus far, they are useful for identifying materials only. We are still in need of methods having a higher degree of discrimination.

We may hope that the near future will see many of our present difficulties resolved.

A Direct-reading Explosion-effect Gage

By NORMAN J. THOMPSON, Director, and EDWARD J. COUSINS, Research Engineer,
Factory Mutual Laboratories, Boston, Mass.

On account of the large annual loss caused by explosions of combustible dusts and vapors in industrial processes, there has been much investigation into the hazards of the various materials which can cause such explosions. The Factory Mutual Laboratories are interested not only in the hazards of any particular material, but also in how to construct and protect buildings so that damage will be minimized should an explosion occur. Small-scale tests to determine maximum explosion pressures obviously cannot be used to evaluate the effect of an explosion in a building. On the other hand, final remedies can be found by running explosion tests on a scale and in such intensity as to destroy ordinary buildings, modifying the construction or providing pressure vents until a safe arrangement is developed. The Factory Mutual Explosion-effect Gage was designed to make such tests practical without actual destruction.

Explosion Test Chamber

In order to conduct research into the hazards of various dusts and vapors and the effect of explosions on building construction at a scale approaching full size, a reinforced concrete explosion test chamber 30×12×12 ft. inside dimensions designed to withstand safely an internal static pressure of 1,000 lbs./ft.^{2} was constructed at the Factory Mutual Laboratories Experimental Station at Norwood, Mass. One end and two-thirds of the roof can be covered with construction under test; and any type and area of explosion vent can be provided.

Use of Pressure-time Data

In considering a test program to utilize this structure, a two-fold problem arises; first, what to measure and second, how to measure it. There have been no other investigations on a comparable scale so that previous experience could not be utilized. Practically all investigators have presented their results in the form of pressure-time diagrams. These measurements were made either with some modified form of a steam engine indicator or with a diaphragm type of gage*. More elaborate electronic gages have recently been devised, principally for other purposes. One type uses a piezoelectric tourmaline crystal as the pressure-sensitive device and, after a high degree of amplification, indicates on a cathode-ray oscilloscope. Another instrument devised for use in recording pressures in automotive engines uses a diaphragm type of gage in which the motion of the diaphragm varies the capacitance of a small capacitor. This equipment also indicates on a cathode-ray oscilloscope after suitable electronic treatment. In both instruments the results are recorded photographically on a moving-film camera.

The manometer developed by the United States Bureau of mines is typical of the more simple pressure recorders. In it the motion of a diaphragm exposed to the explosion pressure is magnified by the deflection of a concentrated beam of light on a small mirror attached to the back of the diaphragm. This deflection is recorded on a sheet of photographic paper wrapped on a rotating drum.

Having obtained a pressure-time diagram by some suitable means, it is

*H. F. Coward and M. D. Hersey, "Accuracy of Manometry of Explosions," U. S. Bureau of Mines *Report of Investigations*, No. 3274, May 1935.

then necessary to estimate the damage which a similar explosion would have caused to any given type of construction. Evaluation of an explosion to this extent was seldom, if ever, attempted. The intensity or destructiveness of the explosion was described by the peak pressure produced, the duration of the positive pressure, the area under the pressure-time curve or the rate-of-rise of pressure or by some combination of these quantities. However, none of these values, either singly or in combination, can give more than a general idea of destructiveness because the effect of any particular explosion will depend upon what it is working against. When considering explosions in buildings, the question is, "Will the construction withstand any explosion which may be expected to occur in it, and, if not, what pressure venting means or what modifications to the structure will be needed?"

Direct Test Methods

It is, of course, possible to make full-scale tests to determine the answers to these questions. Testing in this way would be very expensive, but this is not the greatest objection. For example, if the construction in question is a brick wall, it will take several days to build the wall and then several weeks for it to age and possibly only one test could be obtained, after which it would be necessary to rebuild the wall and wait for another long period before another test could be made. The best solution is to use a dynamic model of the construction under investigation.

For a scale ratio of unity the model would have to have, under equal load, the same deflection as the proposed construction. It should also have a mass per unit area exposed to the explosion equal to that of the prototype. Without any mathematical analysis it can be seen that under these conditions and with equal applied forces the model will move in exactly the same fashion and the same amount as the construction in question. Mathematical treatment of this problem shows that the proper combination of weight and deflection at scale ratios other than unity requires the natural frequency of vibration of the model to be the same as that of the construction.

If a true dynamic model of the construction in question was exposed to an explosion, and if the measured deflection exceeded the deflection which would produce a stress in the actual construction at the elastic limit, such an explosion would have seriously damaged the construction. The model cannot give more information than this because similarity exists only up to the elastic limit of the actual construction. So little is known of the behavior of most structural materials beyond the elastic limit that it is impractical to design a gage which will simulate the action. This, however, is not an important failing of the gage since most construction which has been stressed beyond the elastic limit must be replaced; and, therefore, to exceed such a stress constitutes a virtual failure of the construction.

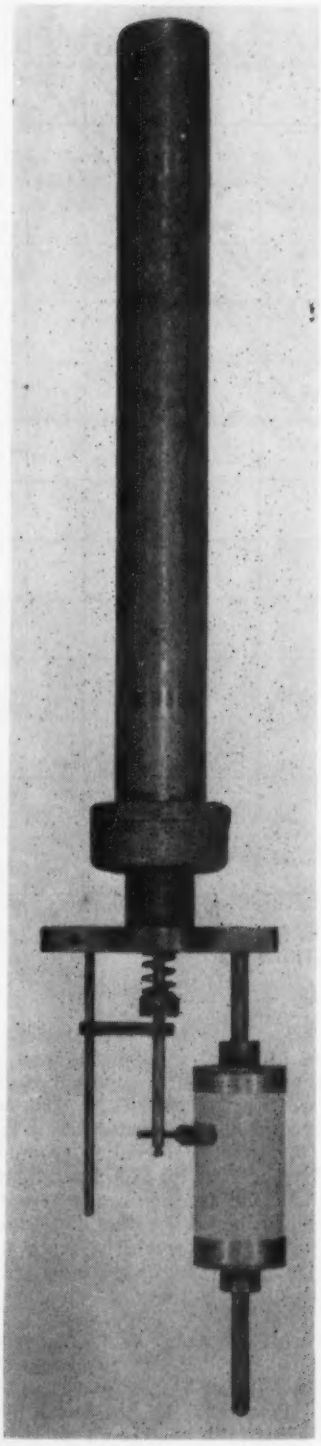


Fig. 1

When using the Factory Mutual gage to measure relative explosion intensities the elastic limit factor does not enter. As will be subsequently shown, the gage can be considered a scale model of any construction which has the same natural frequency of vibration, the scale depending on the relative mass per unit area of construction and gage. Consequently, it may be assumed that the gage is a model at a reduced scale of some imaginary construction which will withstand any explosion without exceeding the elastic limit. Under these conditions the destructiveness of the explosion against construction of this natural frequency is directly proportional to the deflection.

Design of Factory Mutual Gage

In addition to giving an indication directly proportional to the destructive effect of an explosion, consideration of the practical use shows that the gage should also have the following desirable characteristics:

1. The indication should be immediately available without special processing such as photographic development or lengthy mathematical analysis.
2. The instrument should not be adversely affected by external vibration nor by the heat of the explosion.
3. It should not be seriously affected by corrosive fumes nor fouled by dust.
4. It should be easily mounted so as to place the sensitive element at or near the inside face of the wall of the test structure.

A gage built to meet these conditions is shown in Figs. 1 and 2. The body of the gage is a stainless steel tube 2″ outside diameter, wall thickness 0.083″, which fits inside the 2″ pipe extending through the test chamber wall. The gage is held in place by a pipe cap which screws on the pipe and bears against the end fitting. A length of 6″ at the inside end of the tube is ground

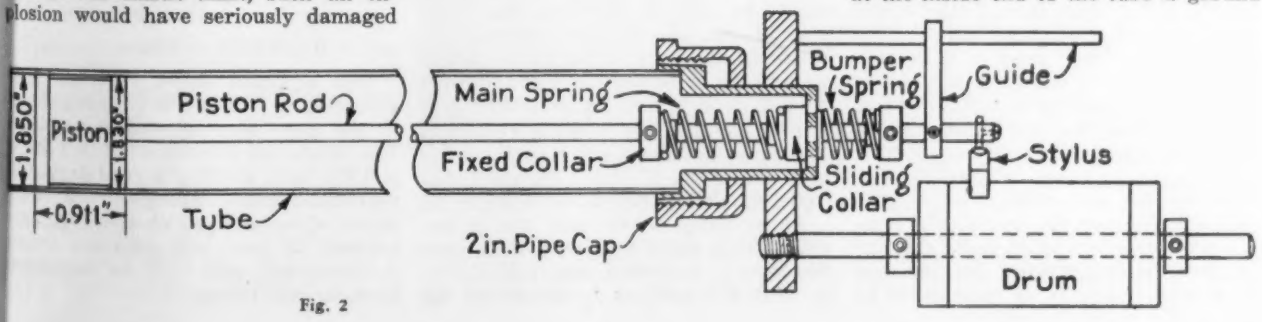


Fig. 2

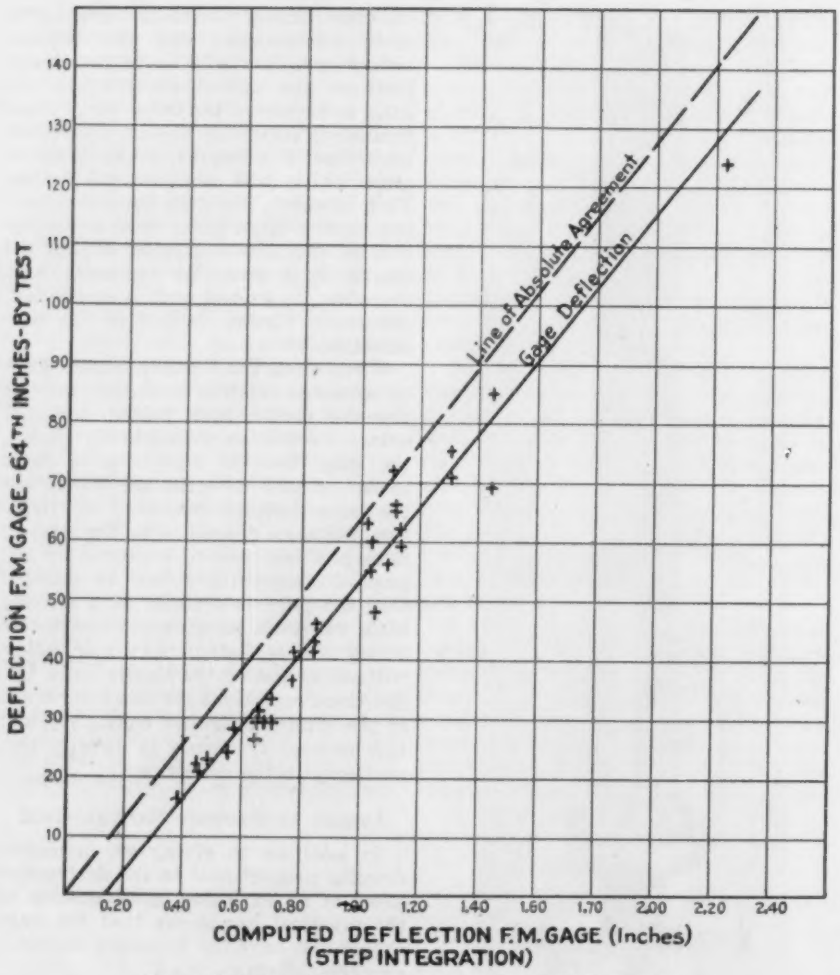


Fig. 3. Deflection of F.M. Gage Test vs. Step Pulse Integration.

and polished to an inside diameter of 1.850″ to receive the piston, which is 1.830″ in diameter with six V-shaped longitudinal grooves for 3/16″ bearing balls. There are 18-gage plates at the ends of the piston to retain the balls. The piston rod extends through the end fitting and carries a stylus which records on paper wrapped on the drum. Movement of the piston under explosion pressure is resisted by the main spring which acts between the collar fastened to the piston rod and the end fitting. The bumper spring cushions the shock of the return stroke. The guide keeps the stylus in contact with the paper.

In the model described, in order to represent average good construction, the weight of the piston and moving parts, and the strength of the main spring, were chosen to represent a brick wall 12″ thick and 16′ between supports. The strength and elastic constants of brick walls were derived from data given in the Bureau of Standards Report BMS5. In the tests covered by this report three walls each, of three types of brick walls, were tested. The modulus of elasticity varied from 129,000 lbs./in.^{2} to 950,000 lbs./in.^{2} with an over-all average of 460,000 lbs./in.^{2}. The average modulus of elasticity for the wall of so-called average construction was 400,000 lbs./in.^{2} and an average modulus of rupture of 53 lbs./in.^{2}. Applying these latter constants to a 12″ thick brick wall on a 16-ft. span, the natural period of vibration of the wall would be 6.96 cycles per second and the deflection at cracking, under static loading, would be 0.08″ at a load of 37.5 lbs./ft.^{2} (0.26 lbs/in.^{2}). the extreme range of natural frequency based on the data for all the walls tested would be from 4.0 to 10.7 cps. In designing the gage the modulus of elasticity of the average wall (400,000 lbs/in.^{2}) was used giving a natural frequency of 7 cps.

Using 120 lbs./ft.^{3} as the average weight of brickwork, the prototype wall would have a weight per square inch of face of 120/144=0.833 lb. so that the effective weight per unit area is 17/35×0.833=0.404 lb./in.^{2}. Therefore, with a piston of 2.69 in.^{2} area, the weight of the piston and moving parts should be 0.404×2.69=1.085 lbs. Using 400,000 lbs./in.^{2} for the modulus of elasticity of the wall the static deflection of the brick wall as a simply supported beam would be x=0.199″ (remembering that the effective weight is 17/35 the actual weight) so the stiffness coefficient K of the spring in the model should be 1.085/0.199=5.46 lb./in.

As actually constructed the piston and moving parts weighed 1.18 lbs. and the spring coefficient was 5.85 lb./in. so that the natural frequency of the gage was 6.98 cps. and the scale ratio is 1.085/1.18 = 0.92.

Comparative Tests

Through the coöperation of the Underwater Explosives Laboratory of Woods Hole, Mass., the precision and accuracy of the gage was checked in a series of tests in the explosion test chamber in which pressure-time curves were taken with a cathode-ray oscillograph for each explosion using a tourmaline crystal pressure pick-up located within a few inches of the gage. From the pressure-time curves thus obtained, the expected deflection of the gage was computed and compared with the actual gage deflection. This comparison is shown graphically in Fig. 3. In order to be conservative, the computed deflection was assumed correct and all error was ascribed to the gage. This assumption disregards two important possible sources of error in the computed deflection; that is, error in the pressure-time curves and error due to the assumptions necessary to make computation possible.

Although the tourmaline crystal pressure pickup and associated equipment was the best available and was operated by experienced personnel, there was of course some random error in the measurements. The actual pressure-time function is impossible to use mathematically, on account of its complexity; and approximations must be used. There are various approximations to the pressure-time curve such as exponential decay curves and triangles of various proportions which can be used. However, for this purpose a closer approximation was desired. The photographically enlarged pressure-time curves were planimetered and the average pressure for each 10 millisecond interval was found. The motion of the piston was then computed assuming the pressure constant over each interval.

Analysis of Principle

Inspection of the plotted points of Fig. 3 shows that the indication of the Factory Mutual gage is less than the theoretical by a nearly constant amount over a wide range of deflection, this difference being due to friction. Correlation of the 31 points by "least squares" gives an equation for the instrument readings (in 64ths of an inch) of $Y = 0.973X - 9.01$, where

Y = reading of F.M. gage in 64ths inch;

X = true deflection in 64ths inch.

Solving for the true deflection,

$$X = 1.028Y + 9.26$$

This equation shows that the true deflection is within 3% of being equal to the gage reading plus a constant. The "Standard Deviation" of this series is 0.070 inch, showing a good degree of reproducibility. Throughout a long series of tests in which the gage was exposed to dust and corrosive fumes it functioned with only an occasional cleaning and oiling.

Calibrated Gas-flow Resistors

By JENS SIVERTSEN, Chief Engineer, George E. Fredericks Co., Bethayres, Penna.

IN production work as well as in laboratory research, an oft-met problem is that of bleeding a small amount of gas at low pressure into a tube or chamber—and to do this in a definite predetermined time. This subject of controlled gas flow in vacuum apparatus has, of course, been treated theoretically and experimentally long ago by eminent physicists (M. Knudsen, W. Gaede and others) but it seems that many workers are unaware of the simplicity of the mathematics and of the procedure.

A calibrated gas flow resistor is an open tube which, connected between two gas chambers, will admit a definite amount of the gas to pass in unit time from the chamber with the higher pressure to that with the lower pressure.

The analogy with electrical resistors is almost perfect for vacuum work. The following shows the similarity between the formulas for flow of electricity and of gas:

$$I = \frac{E}{R} = \frac{E}{\rho(L/A)}$$

I = Electric current
E = Potential difference between ends
R = Electrical resistance
ρ = Specific resistance
L = Length of resistor
A = Cross-sectional area of resistor

$$Q = \frac{P}{\rho^{1/2} W}$$

Q = Gas flow
P = Pressure differential
W = Constant dependent on form, size, shape and length of resistor
ρ = Constant dependent on the gas

We can calibrate a gas-flow resistor for a specific pressure differential, for example 760 mm. of mercury (P_{760}) and a definite gas, for example air.

$$Q_{760} = \frac{P_{760}}{\rho^{1/2} W} = \frac{1}{T_{760}}$$

where Q_{760} is a constant which pertains to the calibrated resistor and designates how many cm.^{3} of air will flow through per minute with a pressure differential of 760mm. of mercury, and similarly T_{760} describes how many minutes it takes for 1 cm.^{3} air to flow through under the same conditions. Therefore,

Q_{760} represents the admittance of the resistor,
T_{760} represents the resistance of the resistor.

For some other pressure (P_x) we have

$$T_x = T_{760}\ (760/P_x)$$

For some other gas we have

$$Q_x = Q_{760}\ (P_x/760)$$
$$T_{ox} = C_o\, T_{760}\ (760/P_x)$$

where C_o is a constant which can be experimentally determined for most gases and which depends on molecular weight and structure.

If N gas flow resistors are connected in parallel, the resultant flow

$$Q_N = Q_1 + Q_2 + Q_3 + \ldots\ldots + Q_N$$

$$\text{and } T_N = \frac{1}{Q_N}$$

If M resistors are in series

$$T_M = T_1 + T_2 + T_3 + \ldots\ldots + T_M$$

$$\text{and } Q_M = \frac{1}{T_M}$$

With a limited number of gas flow resistors, it is therefore possible to obtain a very large number of flow rates by either series or parallel connections or series-parallel connections. The resultant flow rate can be predicted by simple arithmetic. For series connection, we add the time constants and obtain the time it takes for 1 cm.^{3} to flow through. The reciprocal of the sum is the resultant flow rate. For parallel connection, we add the flow rates and obtain the resultant flow.

This simple figuring has a practical significance. Accurate and reliable gas flow resistors (or vacuum leaks) are not available in an infinite number of flow rates. An experimenter, therefore,

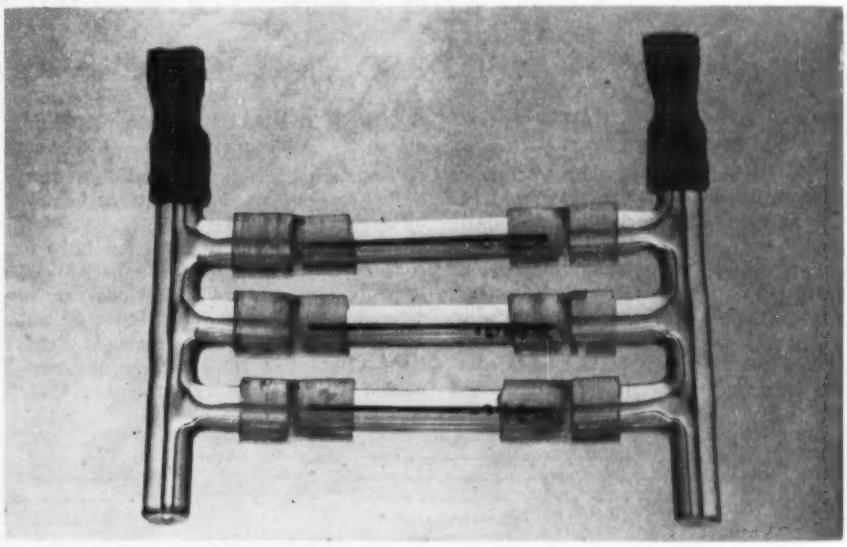


Fig. 1. Three gas-flow resistors arranged in PARALLEL between two glass manifolds. The top connection on each manifold is sealed off by means of a cap. The bottom openings are used for connection to the gas system.

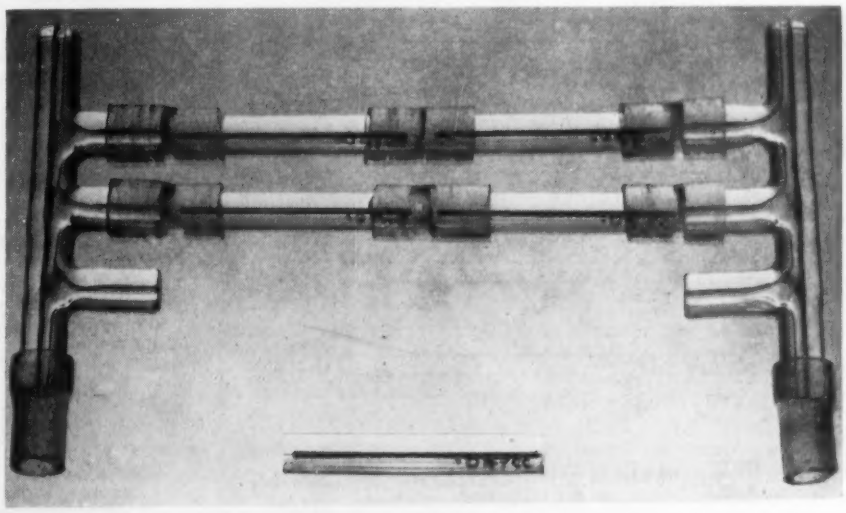


Fig. 2. The same two glass manifolds as in Fig. 1, with four gas-flow resistors in SERIES-PARALLEL connection. The free connection tubes of the manifolds should of course be closed off with caps as shown in Fig. 1. At the bottom of this picture is shown a new "non-clogging" type of gas-flow resistor.

may have to take what is available, as with small electrical resistors. With the electrical resistors, however, the exact value can be obtained by series or parallel connection. The same procedure can also be used regarding gas flow.

Fig. 1 shows three gas-flow resistors arranged in parallel between two glass manifolds. The top connection of each manifold is sealed off by means of a cap. The bottom openings are used for connection to the gas system.

Fig. 2 shows the same two glass manifolds arranged with four gas flow resistors in a series-parallel connection. The free connection tubes of the manifolds should be closed off with caps as shown in Fig. 1. At the bottom of the picture is shown a new "non-clogging" type of gas flow resistor.

The practical and sad experience of many experimenters may reject the idea of having any formulas to apply in connection with gas-flow resistors, because of their constantly changing constants. The flow rates through old type resistors are unstable due to clogging. The result was sometimes so bad that the resistor clogged up completely. This was, of course, due to the small hole which had to be used in order to obtain the low flow rates generally desired. Recently a U.S. patent has been granted on a new type of gas flow resistor which will retain its flow rate accurately. The cross-section of the opening in these new resistors is not a circular opening where a dust particle might cause a clogging, but is a ring opening. Owing to the larger circumference of the ring, its radial dimension is too small for most dust particles to enter, and if any should enter they will only occupy a spot in the longitudinal direction of the resistor and have no measurable effect on the flow rate. Experiments, and use over nearly three years, have verified this claim. The resistor may also change with temperature. This is, however, a linear function and can, therefore, be accurately figured.

True and False Indications of the Phase Sequence Meter

By CARL T. GRAUER, Oakland, Calif.

THOUSANDS of phase sequence meters, of both the glow and the rotating-disk variety, are in daily use by electrical workers, and are depended upon to indicate phasing of polyphase circuits. When properly used, in conjunction with other identifying methods, these instruments will show correct phasing. One of the most common uses is to determine the forward or reverse direction of induction motors before making final connections in new or supplementary circuits.

Where direction of rotation only is concerned, the rotating-disk instrument is preferable and its indications can be depended upon to show whether or not a motor will rotate in its forward direction. Control devices which are connected to such motors, and have their control relay coils connected across one phase of the motor supply without connections to a neutral or a ground, will operate independently of phase sequence, and the only function of the correct phasing will be to ensure proper rotation of the motor.

However, if a control circuit involves relay holding coils, which are connected from line to neutral or ground, as may

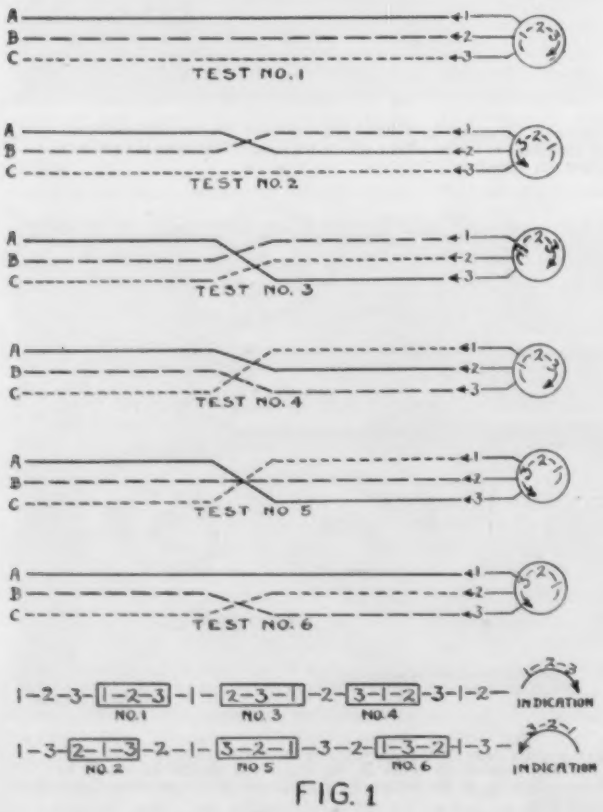


FIG. 1

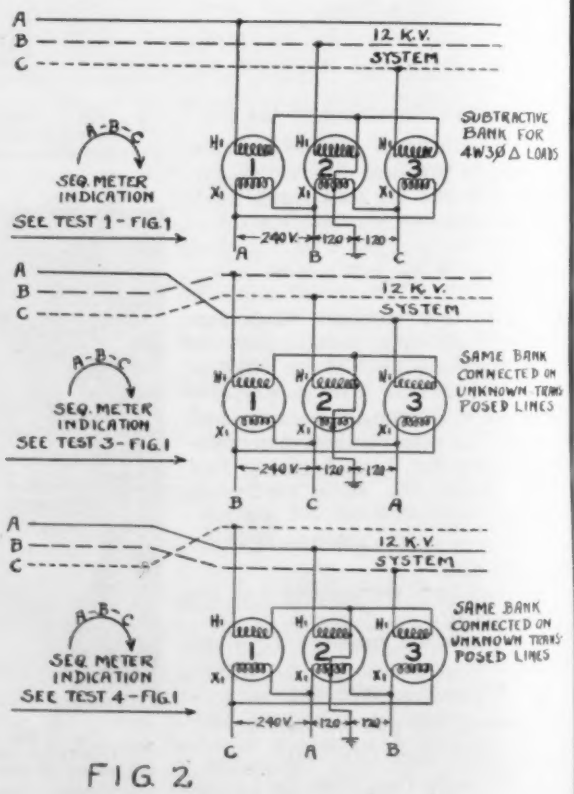

12 K.V. SYSTEM
SUBTRACTIVE BANK FOR 4W3Ø Δ LOADS
SEQ. METER INDICATION
SEE TEST 1 - FIG. 1
240 V
120
120
SAME BANK CONNECTED ON UNKNOWN TRANSPOSED LINES
SEQ. METER INDICATION
SEE TEST 3 - FIG. 1
SAME BANK CONNECTED ON UNKNOWN TRANSPOSED LINES
SEQ. METER INDICATION
SEE TEST 4 - FIG. 1

FIG. 2

be encountered on a 3-ϕ 4-wire circuit, there is a possibility of false indication of the phase meter where the power supply is taken from more than one transformer bank. If only one supply source is in use, then the customary procedure of taking out a grounded neutral from one transformer in the bank, then using the phase sequence meter to indicate the rotation, will cause no difficulty in identifying the phases.

The correct procedure would be to measure, with a voltmeter, the voltage from ground to the 208-volt or HOT leg of a 240-volt 4-wire 3-ϕ system. This hot leg could then be assigned a number 1, and the No. 1 lead of the sequence meter tied to that point. The other two sequence meter leads should then be connected to the remaining phase wires. Indications of the phase meter of 1-2-3 could then have these numbers assigned directly to the remaining phase leads, the phase lead numbers corresponding to the sequence meter lead numbers. If the sequence meter reads reversed or 1-3-2, it is of course merely necessary to reverse one phase. Thus the identification for a single bank is quite simple.

When, however, more than one supply bank is used, as one often encounters in large installations which are scattered over considerable territory, it is possible to have false indications and large voltage differences between phases which one would expect to be identical. This condition is caused by improper phasing, or by assuming that *A*, *B* and *C* phases appear in identical order in any location, not allowing for any possible unknown transpositions.

Fig. 1 shows how misleading a phase sequence indicator can be when it is depended upon to show which lines are identical at different locations, on the same system. So far as the rotation is concerned, two wrongs make a right.

Fig. 2 shows how the rotation indication can be misleading when the three transformer banks, each of which shows the same rotation, are actually connected, unit for unit, to different phases. These banks have been connected in what was supposed to be identical connections, the mid-point of each center transformer grounded, and then the sequence checked by observing the rotation of the phase sequence meter.

Fig. 3 shows the vector relations of two of the three units shown in Fig. 2, where different phases are connected to apparently identical transformer banks.

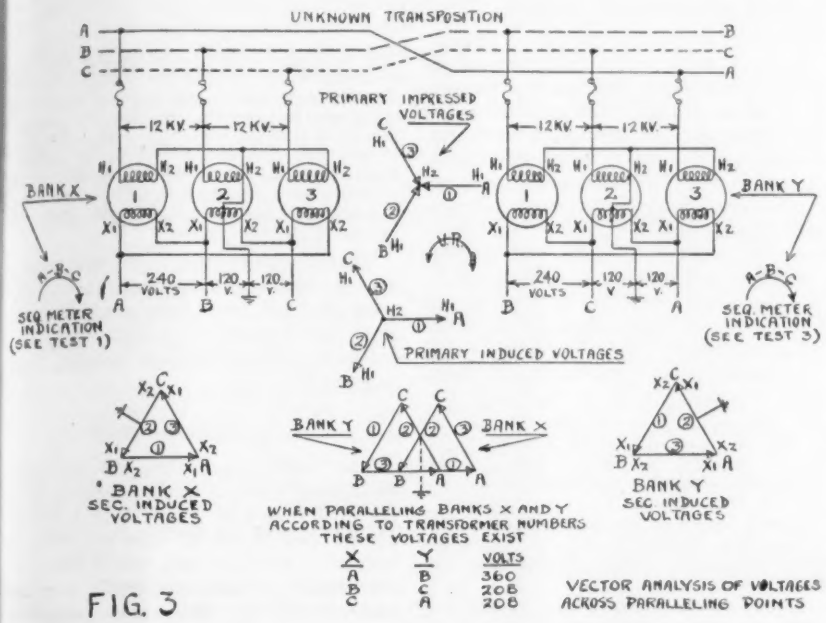

UNKNOWN TRANSPOSITION
PRIMARY IMPRESSED VOLTAGES
12 KV
BANK X
BANK Y
240 VOLTS
120 V.
SEQ METER INDICATION (SEE TEST 1)
SEQ METER INDICATION (SEE TEST 3)
PRIMARY INDUCED VOLTAGES
BANK X SEC. INDUCED VOLTAGES
BANK Y SEC. INDUCED VOLTAGES
WHEN PARALLELING BANKS X AND Y ACCORDING TO TRANSFORMER NUMBERS THESE VOLTAGES EXIST
X Y VOLTS
A B 360
B C 208
C A 208
VECTOR ANALYSIS OF VOLTAGES ACROSS PARALLELING POINTS

FIG. 3

As long as there is no interconnection or paralleling of these two banks, no difficulty will be encountered except an insulation stress between the various points as shown. Note that between the left hand end secondary leads of these two banks, a voltage of 360 volts exists, while voltages of 208 volts can be measured between the remaining similar points which would normally be connected together if parallel connections were necessary to carry an increased load.

There are some 3-ϕ 3-wire delta 460-volt circuits where one corner of the delta is grounded. If two such banks are connected on the basis of similarity, as in the connections of Fig. 2, still larger voltage differences will appear across the normal tie points. This is shown in Fig. 4. The ratio of both banks is identical but voltmeter tests will indicate 796 volts between two normally zero tie points.

Where lines are extended and carefully marked as to phasing, the sequence meter can be relied upon after the ground connection has been made, or tested in some practical temporary manner before final connections are made. Where the lines are not marked, or where there is reason to suspect that they are improperly marked, then such a temporary ground connection should be made, and a small line run to the nearest established bank for voltage testing purposes.

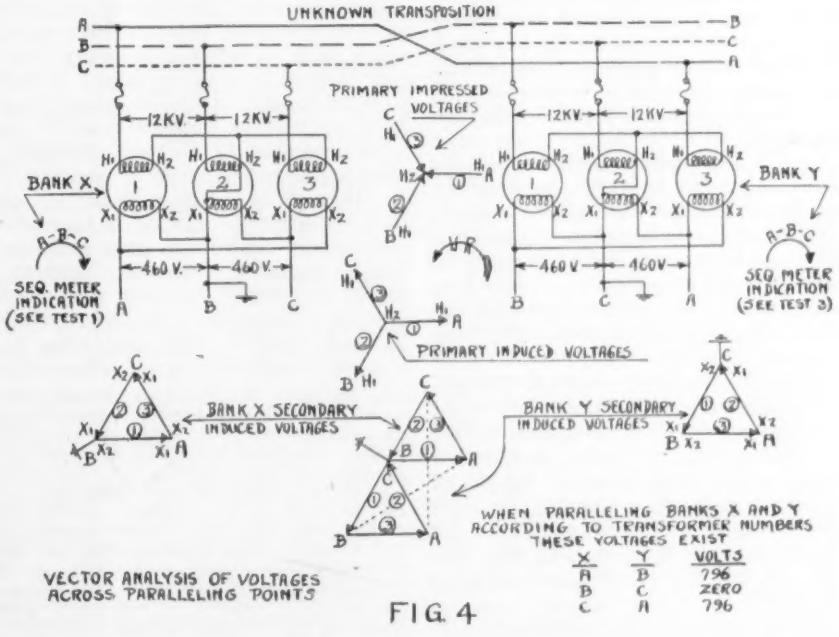

UNKNOWN TRANSPOSITION
PRIMARY IMPRESSED VOLTAGES
12 KV
BANK X
BANK Y
460 V.
SEQ METER INDICATION (SEE TEST 1)
SEQ METER INDICATION (SEE TEST 3)
PRIMARY INDUCED VOLTAGES
BANK X SECONDARY INDUCED VOLTAGES
BANK Y SECONDARY INDUCED VOLTAGES
WHEN PARALLELING BANKS X AND Y ACCORDING TO TRANSFORMER NUMBERS THESE VOLTAGES EXIST
X Y VOLTS
A B 796
B C ZERO
C A 796
VECTOR ANALYSIS OF VOLTAGES ACROSS PARALLELING POINTS

FIG. 4

The conventional phase numbering, lettering or color-coding will save time in allowing identical phasing on all banks tied to a large system, but such marking, if not made with care at all times, can result in unusually large voltages at paralleling points.

A New Method of Measuring Relative Humidity

By FRED LICHTGARN, Chicago, Illinois

THE measurement of humidity is becoming of increasing importance in continually-expanding fields. Perhaps the greatest potential field is weather forecasting, where little is known, comparatively speaking, about the exact measurement of water vapor under open-air conditions, because no suitable means have been available to do so. Another promising field is industry—especially cold-storage, etc., where there is no satisfactory method for measuring humidity at temperatures below the ice point.

Probably the earliest known method of measuring humidity was by the use of human hair stretching and contracting with changing humidity. This is a common method still used today. Strands of hair with mechanical levers and linkages are widely used in humidity control. The hair type of instrument has many advantages such as cheapness, simplicity and compactness. Another method employs a piece of goldbeater's skin in place of hair. Another means of measuring humidity is by the expansion and contraction of a piece of selected wood. There are perhaps hundreds of other materials which change in some physical way under changing humidity. Treated and coated papers also come under this classification. All these types have a fair degree of accuracy and sensitivity but their accuracy is not permanent because their characteristics change with high or low temperatures and even with high humidity.

A more scientific method is by the use of wet- and dry-bulb thermometers. This method is considered accurate except where the air to be measured is near or below the freezing point of water. Some errors tend to creep in—such as the rate of air flow past the wet bulb, dirty wicks, amount of wick exposed to air and the personal errors in reading the thermometers. The air-circulation error is minimized by using a standard sling psychrometer. It may be of interest that there is disagreement as to the accuracy of the official psychrometric tables and that one large firm worked out a set of tables for their own use because they felt that the official tables were not accurate enough.

Other methods of measuring humidity are the chemical methods: hygroscopic chemicals absorb water vapor from the air and the amount so absorbed is weighed carefully. This is a laboratory method and, in unskilled hands, errors can creep in when such an indirect and involved procedure is used.

Some patents have been granted on using hygroscopic chemicals held onto an asbestos support and measuring the adsorption and desorption of water vapor by the change in electrical resistance. (Some of the chemicals used are chromium trioxide, ammonium chloride, and potassium nitrate.) The writer spent several years experimenting with chemicals and crystals and, although he did get some remarkable results, the disadvantages finally forced him to develop a better method. Some of the shortcomings of hygroscopic-chemical methods are:

1. The chemicals used seem to "poison" by foreign matter or gases or by the passage of the electric current. The chemical gradually loses its sensitivity and its calibration.

2. The electrical contacts contacting the hygroscopic chemicals seem likely to develop resistance changes which alter calibration.

3. The chemicals themselves are not permanent or stable when exposed to air.

4. Most chemicals become deliquescent under high humidity conditions, and a change in calibration is sure to follow.

5. Each chemical covers only a limited range.

6. Chemical methods are "messy," unreliable and usually controllable only over short periods of time.

Nevertheless the writer believes that hygroscopic-chemical primary elements have a promising future. The reason, which may be inferred from the foregoing list of their shortcomings, is that they are capable of *extreme sensitivity*. Many of them are sensitive to small and rapid changes in relative humidity, though responding much too sluggishly to *decreases* in humidity. Inasmuch as high sensitivity is desired in laboratories, where man-hours and expenses can be spared to offset the disadvantages, the writer deems it proper to disclose briefly some of the experiments he made several years ago, when he was still experimenting with chemicals:

1. An early chemical-type element was sealed, with some phosphorus pentoxide, in an ordinary fruit jar. After two days of drying, when the associated electrical instrument read zero humidity, the jar cover was given a half-turn: the instrument instantly shot up to full-scale reading. Of course, the sensitivity of the instrument had purposely been adjusted high in order to observe what was expected to be a gradual change of indication with the extremely slow diffusion of water molecules from the fairly dry room atmosphere, but the speed of response was startling.

2. A dry piece of No. 18 wire was wetted, wiped dry with tissue paper and quickly brought close to a chemical-type element: the immediate response of the instrument pointer showed that the element instantly responded to the almost infinitesimal amount of water vapor evaporating from the invisible surface moisture which the tissue had not entirely removed.

3. A single crystal—almost too small to be seen—when used in an element for an experimental radiosonde system responded satisfactorily within a narrow range, though it was useless above and below this range. For radiosonde and other applications requiring light weight, a *graded series* of many such elements could be built under a microscope and the total weight might not exceed a quarter-ounce.

These experiments — and many others—indicate that research and development will eventually produce chemical-type elements of usefulness to scientific workers capable of keeping them in good condition.

Electrical Methods

The earliest non-chemical electrical resistance change method was devised about the time of World War I. It employed two pieces of bare wire wound around a metallic tube which was covered with various materials such as cloth, tape, etc. The wires served to "contact" the cloth or tape and measure the change of resistance as the humidity changed and the cloth became more or less conductive. Another patent was granted for an almost identical method wherein two pieces of cotton-covered "bell wire" were wound on a tube and the humidity altered the resistance of the cotton, the resistance change being measured on a microammeter.

These methods are crude; they are subject to many errors; they respond only in the higher humidities such as above 50% R.H. They are affected by temperature changes which contract the wire and consequently the amount of cloth "contacted," etc. They are relatively inaccurate and are inherently slow in response. They never came into general use.

Almost everything will change somewhat in electrical resistance under changing water vapor conditions. Under high humidity conditions (over 75% R.H.) many things serve as excellent resistance-change elements. Pieces of ordinary glass and glazed porcelain, if connected to a vacuum-tube voltmeter, exhibit extremely fast response. There are patents issued for this type.

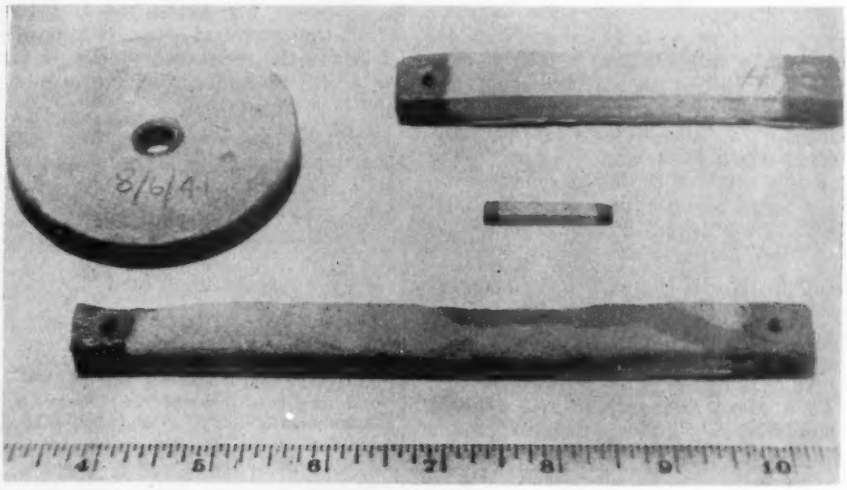
These electrical change units depend mainly on the amount of water vapor adsorbed by purely physical means. Water vapor in air tends to cling onto or, in other words, to be adsorbed onto *surfaces* of solids. The difficulty has been that not enough surface has been so contacted or else that the surface had too little affinity for water vapor and therefore only a slight amount of water vapor is absorbed. This is the reason why hygroscopic chemicals are

used: they at least can gather enough water vapor to measure.

The writer became interested in humidity-responsive elements for radiosondes in 1938. Human hair was used in some instruments; hygroscopic-chemical type electrical resistance elements in others. The chemical type has been made of two lengths of bare wire wound around a thin aluminum tube about 1½" in diameter. The tube is covered with a layer of pure rubber applied by dipping. The wires are wound consecutively around the tube on this rubber layer. A 5% to 7% solution of lithium chloride covers the wires and the space between the wires acts as the resistor responding to humidity. The hair loses its sensitivity in cold weather; the chemical-type element lacks stability, requires individual calibration and is subject to some of the faults listed previously. To find a better element for the radiosonde is quite an undertaking in view of the extreme cold encountered in the upper air, the wide range of 20% to 100% R.H., the weight limitation, the required sensitivity and the narrow range of resistance change allowed by circuit requirement.

Early in his experiments, the author made some elements in the form of dissimilar metals separated by some absorber which acted also as an insulator, so that a very feeble emf. was generated chemically and was a measure of the water vapor. This method was not entirely abandoned, but it occurred to the author that it would require something as fine as the arrangement of atoms in crystals to serve as the most efficient trap for the water vapor.

At first, various crystals were tried out with a small voltage applied across them and with a vacuum-tube voltmeter as an indicator: nearly perfect indications of the humidity (within limits) were obtained. Ammonium nitrate and sodium bromide crystals responded best of all. Unfortunately, these elements would not hold calibration long enough to qualify for important applications such as radiosondes. Then, the author was struck by the fact that powdered metals (powdered tantalum in particular) adsorb so much water vapor that in order to store the powdered tantalum it has to be kept in tightly-closed metallic containers. With this thought in mind an element composed of alternate particles of tantalum and of some insulator was planned. (An insulating material had to be used as binder because powdered metals alone would have so low a resistance that the addition of moisture would not be measurable.) As binding materials, clay and kaolin were tried, along with various cements and plaster-of-Paris mixtures. The first elements, a mixture of powdered iron and graphite in plaster-of-Paris, responded very well. The next elements tried out, iron and chromium oxides mixed with clay and kaolin, were molded by hand into sticks about ⅜" square and 4" long, air dried and then fired for 60 hours at 1700°F. Electrical connections were made by painting colloidal graphite onto ½" at each end: the Aquadag soaked into the porous elements. Several samples of this type of element were tested over 2000 times against a sling-psychrometer for over a year in the range of 35% to 100% R.H. The results were gratifying. These elements were connected to the grid circuit of a specially-designed vacuum-tube voltmeter with a top grid connection tube and an input resistance of 40 megs. One of the elements, placed outdoors in the winter of 1941-1942, gave excellent response over extremely wide changes of humidity and at temperatures as low as —10°F.



Typical experimental elements.

Desired Characteristics

Further study and experiment unfolded the conditions for good design, construction and performance of the new type of element. They are as follows:

1. Water vapor should be adsorbed by the surface of the element.
2. The ratio of total surface to volume should be high.
3. The adsorbed water vapor should change the electrical resistance of the element.
4. The element material must release water vapor just as readily as it will adsorb it.
5. The element must achieve an automatic temperature balance.
6. The element must be physically strong and chemically inert.
7. The accuracy of the element must be permanent.
8. The element should respond at low temperatures, down to —10°F.

Expanding the above points: No. 1 is obvious. No. 2 is highly important: in order not to have to resort to hygroscopic chemicals a total surface area of the order of 500 to 5000 square feet can be made available by using several ounces of powdered or colloidal material suitably made up into an element. This enormous surface-to-volume ratio is the basis of the new method of measuring water vapor. In order to get this comparatively enormous ratio the element is made highly porous so that the water vapor has free access to the interior of the mass of submicroscopic particles. One ounce of kaolin, for example, has a total surface of perhaps 5000 square feet, with a bulk perhaps of one or two cubic inches. In this manner enough water vapor is adsorbed to change the resistance of the element appreciably. In previous electrical-resistance elements of a non-hygroscopic nature, the area available for adsorption was measured in square inches instead of square feet. By specifically using highly porous materials, and materials which have a natural affinity for water vapor, a new principle is opened for water vapor measurements. By using electronic amplification, almost any degree of sensitivity can be obtained. This new method is accurate because an exact balance is achieved automatically by the unvarying primary molecular force of adsorption against temperatures: If the water vapor in air increases by the smallest amount the element will tend to absorb a proportional amount of it. Finely-divided ceramic and ceramic-like materials make efficient elements. Ordinary pottery clays have fine particles going into the colloidal state: too small to be seen in visible light microscopes; photographed in the electron microscope they appear to be feather-like or leafy.

Point No. 3.—One can see that it would be possible to get an electrical resistance change if enough water vapor was absorbed in an element, but test results were interesting. Some materials like powdered glass which are known to adsorb water vapor very well will not conduct electricity at all even under conditions of high humidity.

Point No. 4.—The release of water vapor is very important also. Many materials will adsorb freely but will not just as freely release water vapor as conditions change. Early in the experimental work the writer thought

that fritted glass would make an ideal element. It was most surprising to find that it took extreme heat to force out the water adsorbed by fritted glass: the heat of a soldering iron tip was applied about an inch from the fritted glass to drive out the adsorbed water vapor. It may be worth noting that phosphorus pentoxide could not remove adsorbed water vapor from the fritted glass, as a small amount of cobalt chloride as an indicator readily proved. This shows in a very striking manner the tenacious adsorption properties of powdered glass. Underfired clays, kaolins, some metallic oxides and chalks have been found to have the required properties of both adsorbing and desorbing equally. Owing to lack of adequate facilities the writer could not check as many clays as he would have liked to. By underfired clays is meant clays which have been fired below the fusing point of the main constituents, the result being a mass which is structurally strong yet is freely permeable to air.

Point No. 5, the automatic temperature balance, is related to the adsorption phenomenon. In the case of the porous ceramic element this temperature balance works out advantageously. At a given temperature and a given humidity, only a fixed amount of water vapor can adsorb onto the surfaces available for such adsorption: At all times the element is losing some water vapor molecules by evaporation (quite similar to water vapor molecules leaving boiling water in a closed vessel) and at the same time other water vapor molecules attach themselves by adsorption. If the amount of water vapor per unit volume of air (*absolute* humidity) is fixed and the temperature rises, more water molecules will evaporate than can stay adsorbed and consequently the electrical resistance of the element will increase, indicating a change in *relative* humidity. If both temperature and humidity vary, as they do under most conditions, this same natural process takes place and a new balance is quickly found automatically. The finer the physical sections of the element, the quicker the balance takes place. Because of this self-balancing action, this element responds in temperatures where the sling psychrometer cannot give accurate results. This element does not require moving air; it will indicate and measure in quiet air. It may be of interest to report that some experiments seem to prove that a film of liquid water and presumably adsorbed water vapor also in contact with porous wood charcoal will not freeze even at —35° F. The theory of adsorption is not fully understood at present. The use of this new method may help to shed more light on the subject.

Because of the thinness of the water-molecule film, only a minute electric current can be carried through the element continuously. (A much larger amount can be carried safely if it is not continuous.) Too heavy a current passing through the element "boils off" the adsorbed water and causes errors in indications. However, instruments of the vacuum-tube voltmeter type can easily measure the minute currents required. It must also be noted that above 50% relative humidity, enough water vapor is available to replace some of the "boiled off" molecules readily and more current can be safely passed, but as the atmosphere becomes drier it becomes more difficult to use the "standard sensitivity" and larger elements must be used in order to adsorb enough water vapor for convenient measurements. Using several elements in parallel lowers the resistance effectively for work with medium-sensitivity vacuum-tube instrumentation.

Point No. 6.—The new ceramic type elements are physically strong and are relatively chemically inert. Soaking in water for short periods should do no harm. Long periods (years or centuries) probably would change the characteristics, but this has not been tried. Ancient pieces of pottery from the Mound Builder's ruins would probably indicate relative humidity if connected to the proper modern electronic equipment.

ABsorption and ADsorption

For the benefit of those readers of Mr. Lichtgarn's article who are not chemists and may have forgotten the difference, ABsorption is INTO a solid and ADsorption is ONTO the surface only. Furthermore, ADsorption *is* a reversible process, characterized by equilibrium temperatures.—Editor.

Point No. 7.—The new elements seem to be the closest approach to a non-chemical permanent hygrometric element devised so far. In testing for permanence some elements were heated to a red heat and were found to respond perfectly again when they cooled. Other elements were kept in continuous use for months without any noticeable change in response. These elements were set up to measure both indoor and outdoor humidity conditions and were constantly checked with a sling psychrometer. The results were well within allowable experimental error: better than the accuracy of the sling psychrometer.

Other Characteristics

The resistance of most of the experimental elements constructed up to now is more than 1000 megohms for zero humidity and about one megohm for 95% R. H. The resistance value of any element depends upon many factors, such as: (1) size; (2) shape; (3) constituent materials — whether pure ceramics or containing powdered metals, etc.; (4) fineness of constituents; (5) nature and duration of mixing process; (6) nature of molding operations; (7) duration and maximum temperature and temperature-time program of firing process; (8) location of electrical connections; (9) porosity; (10) location of element.

This last factor is important in that, together with size and shape, it permits determining the range of a single element and the practicability of assembling a plurality of elements in parallel or series or parallel-series combinations to suit various conditions.

As a rule, the characteristic curve of an element is a fairly straight line from about 97% to about 35% R.H., with a knee from 35% R.H. and a sharp taper thence to zero R.H. The author believes that it would be premature to publish curves at this time and that the curves of the future commercial elements (representing development by an organization instead of by one worker) will be more satisfactory for use in the field and in industrial plants by persons without special training.

However, experimental elements have been made which had a linear response from 28% to 100% R.H. In general, the more mass to an element (so that more water vapor is adsorbed) the more into the "dry" region the element will show a straight-line response curve. But, the more mass the slower the speed of response. For this reason, future elements are to be made up of many thin-section wafers in parallel. Obviously the thinner the section the faster the response. Small experimental elements have been made which had a two-second response for a change from 90% to 50% R.H. These elements were approximately ⅜" × ⅜" × 1/16". Large elements, under the same conditions, had an average speed of response of about 10 minutes. Undoubtedly future elements will have greatly improved response as the elements undergo development.

Further Remarks

At present, difficulty is being experienced in measuring "100% R.H." because water vapor at this critical state has not been studied enough and because no scientific instrument has been available which had the required accuracy for this condition. It is believed by the writer that water vapor at 100% R.H. could be most advantageously studied by the use of these porous ceramic elements. At this critical state it seems that "under-saturated," "saturated," "over-saturated" or "supercooled" states could all exist. It is believed that porous elements respond and give indications to these states of water vapor where the sling psychrometer is not capable of giving further true response.

Twice . . . .

To The CONTROL UNIT For Positive Control

The Brown *Air-o-Line* Controller is accepted by engineers throughout industry as the outstanding achievement in air-operated control. It consists essentially of the *Air-o-Line* control unit (just above the cutaway chart in the illustration) and the non-bleed booster pilot (lower left). A turn of the graduated dials "tunes in" proportional band and automatic reset—quickly, precisely and without guesswork. Once "tuned in," *Air-o-Line* is fully automatic, lining out control at the exact set point and correcting for all load or throughput changes without cycling or offset.

Features contributing to the instrument's positive control include:

PROPORTIONAL BAND AND AUTOMATIC RESET ADJUSTMENT. Dials are accessible for adjustment without removal of the chart plate. The Proportional Band Dial is calibrated from 1% to 150%—sufficient to provide the flexibility required to meet any control problem. The Automatic Reset Dial is graduated in units from 1 to 10—ample to meet the load change requirements of any process.

CONTROL INDEX SETTING KNOB. Conveniently located at the top of the chart plate or externally, as desired. A 10 to 1 ratio between the index setting knob and the pointer permits micrometer adjustments of the control index.

THE NON-BLEED BOOSTER PILOT RELAY. Precision manufactured to minimum tolerances throughout. The double bellows unit has an area ratio of 5:1 for rapid response to changes in nozzle pressure. Large intake and exhaust ports insure rapid control valve operation. Capacity is 250% greater than the average bleed type pilot. Uses air only when increasing valve pressure, thereby reducing air consumption to a minimum.

Look twice . . . for the features contributing to accuracy of both measurement and control . . . and remember . . . in Brown *Air-o-Line* Flow Controllers they are combined to furnish positive flow control for any process.

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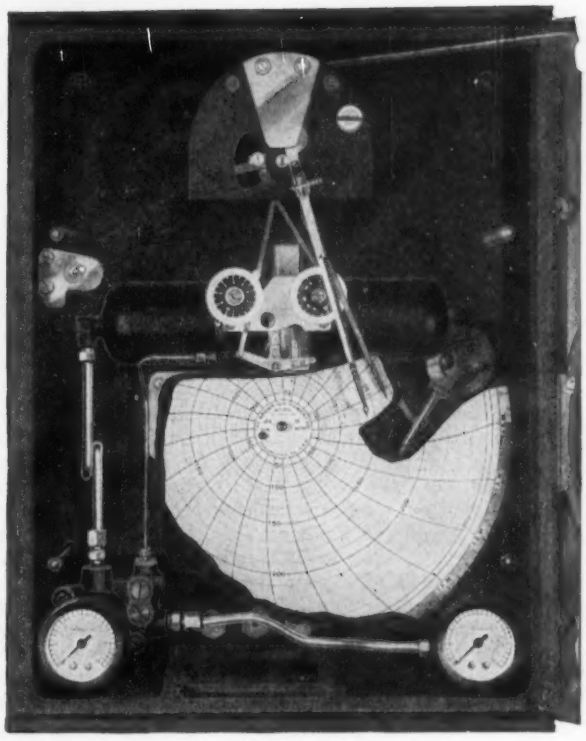
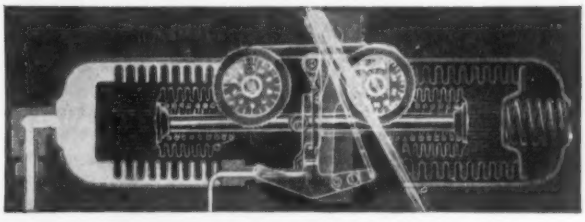
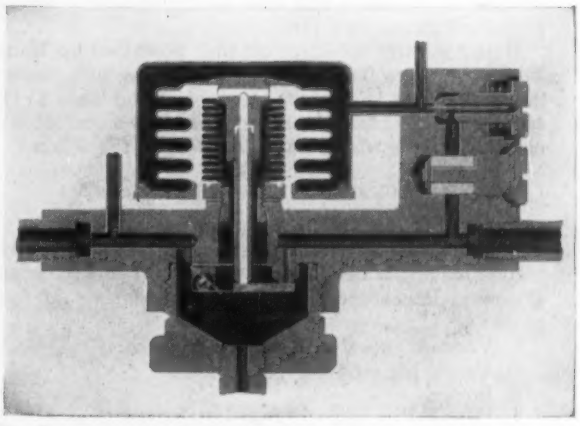


Brown *Air-o-Line* Recording Flow Controller (Chart plate and chart cutaway).



Phantom cross-section of *Air-o-Line* control unit with proportional band and automatic reset; pioneered by Brown engineers.



Schematic section of non-bleed booster pilot relay.

FLOW CONTROLLERS

***Air-o-Line*—THE COMMON DENOMINATOR OF PROCESS CONTROL**

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

XIII. THE MODIFIED MENZIES-WRIGHT MOLECULAR WEIGHT APPARATUS

[This article was prepared in collaboration with Dr. W. E. Hanson, Mellon Institute of Industrial Research.]

The determination of molecular weight is becoming an increasingly common analytical operation. Not only is an exact knowledge of this property important in establishing the structure of or identifying an unknown compound, but it may also serve conveniently to characterize a series of high-boiling cuts in the same manner as the boiling point itself serves for more volatile fractions.

As a specific example, consider the case of a crude oil being separated into narrow cuts by distillation. Throughout the gasoline and kerosene range, fractions are taken according to the boiling point, as this property defines rather narrowly what compounds can possibly be present. As higher boiling material distills, it becomes increasingly difficult and eventually impossible to determine the true boiling temperature. At this point, it is entirely logical to turn to the average molecular weight of the fraction as the basic characterizing property. Until recently, however, this was rarely done, owing to the difficulty and the time required in making satisfactory molecular weight determinations.

As between ebullioscopic and cryoscopic precedure, the latter was generally favored in laboratory work because of its accuracy and its ability to handle materials of widely different volatilities. For substances of higher molecular weight, however, this question of volatility does not enter. Also, because of difficulties attendant upon low solubilities and the tendency for solutes to associate in solvents at their freezing points, several distinct advantages accrue in the use of an ebullioscopic procedure.

The apparatus described below is one which was developed specifically to meet the need for a precise and rapid method for the routine determination of the average molecular weight of heavy petroleum oil fractions. In use it has enjoyed wide application, not only in a variety of routine analytical problems but also in the exacting field of compound structure and identification.

It is basically the same as that described by Hanson and Bowman[1]. Two important changes have been made: A radio tube socket is employed to protect the leads to the press seals and an external heater has been substituted for the original heater which was immersed in the solvent.

Construction of the Apparatus

The molecular weight apparatus is not difficult to make. Production of the instrument does require several techniques among which the glass-to-metal and ring seals are the more important. The apparatus consists of four basic parts:

1. Vacuum jacket and vapor condenser.
2. Vapor lift pump.
3. Boiler.
4. Menzies-Wright differential thermometer.
5. The power supply.

The arrangement of the first four basic parts is shown in Fig. 170. The boiler, pump and thermometer are enclosed in a vacuum jacket to minimize outside temperature effects.

1. Vacuum Jacket and Vapor Condenser

The dimensions of the jacket and condenser are given in the assembly drawing, Fig. 170. These parts are fabricated and assembled as follows:

The inner jacket is made by sealing a 22-mm. tube to a 38-mm. tube. The smaller tube is cut 9 cm. from the seal. The larger tube is cut 20 cm. from the seal. This end is spun out into a flare which fits snugly into a 51 mm. tube.

2. Vapor Lift Pump

The pump consists of a boiler bell, liquid and vapor delivery tube and a liquid and vapor distributing head. A 13-mm. tube is sealed to a tube with an inside diameter of

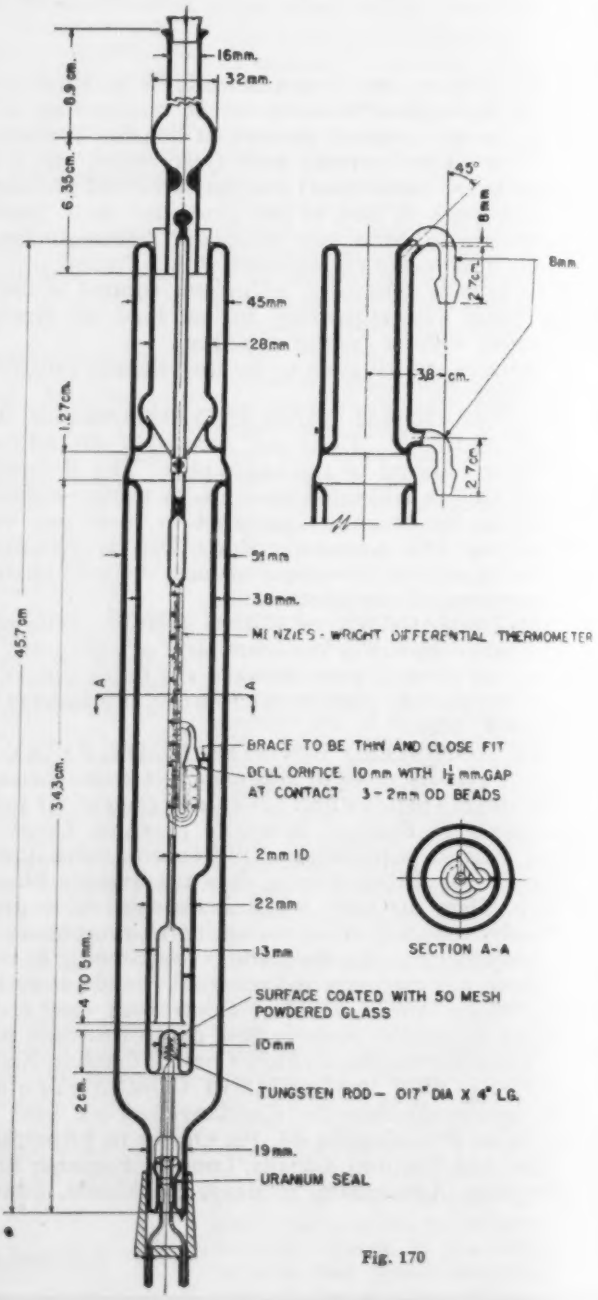


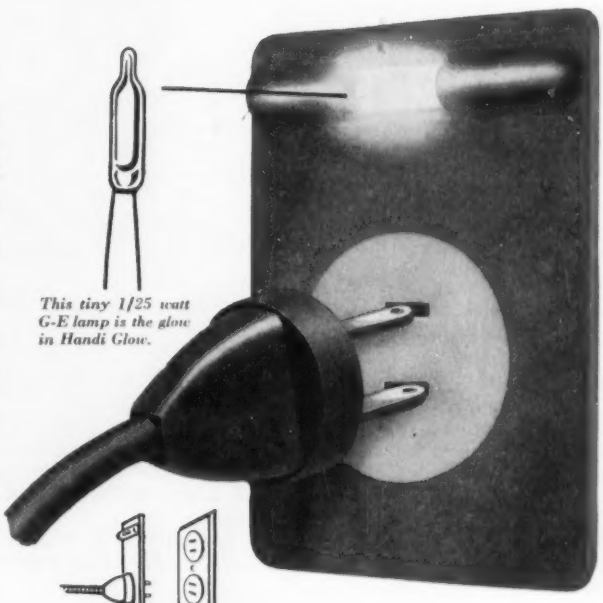
Fig. 170

2 mm. The large tube is cut 5 cm. from the seal and the opening is flared 45°. The liquid and vapor distributing head is made by gathering glass in the small tube at the section 11.5 to 12.5 cm. from the seal. The glass is blown to a bulb with a diameter of 15 mm. and immediately drawn out to form a bell-shaped head. The small tube is then bent

Good news for bad memories

WHAT housewife hasn't put a strain on her husband's good nature by occasionally forgetting to turn off electrical appliances? Industrial Devices, Inc., Edgewater, N. J., has an answer to that universal problem. It's Handi Glow — a simple pilot light attachment that jogs the memory with a visual reminder that the appliance is "on." Fits any standard 2-prong plug. Transfers easily from one plug to another. Also can be used as a voltage test light.

Like many other successful wiring devices, the Handi Glow is equipped with a G-E Neon Glow Lamp— *"the glow that lets you know."*



This tiny 1/25 watt G-E lamp is the glow in Handi Glow.

How Handi Glow plugs in.

...and it's profit news to you!

TYPICAL WIRING DEVICES USING G-E GLOW LAMPS

SAFETY PILOT PLUG *combining nite-lite, 2-way plug and electric cord cap.*

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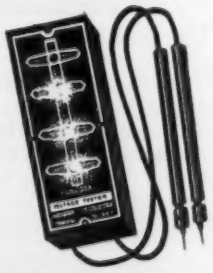
MIDGET PILOT LIGHT *for permanent attachment to instrument panels and electrical apparatus.*



CIRCUIT TESTER *uses G-E Glow Lamps to give quick visual indication.*

THESE few wiring devices merely hint at the hundreds of ways G-E Glow Lamps are used to add sales appeal to appliances, instruments and electrical equipment of many kinds. The following G-E Glow Lamp advantages may suggest a valuable profit opportunity for you, too:

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2. Dependable long life—in some types up to 25,000 hours.
3. Low current consumption—as little as 1/25 watt.
4. Low brightness, low heat.
5. High resistance to shock and vibration.
6. Can be installed in small space.
7. Variety of sizes and wattages.
8. Operate directly from regular 105-125 and 210-230 volt circuits, AC or DC.

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to form an offset just above the seal to the large tube. The tubing adjacent the deformed bulb is then bent in a U-shape, the bend radius being about 5 mm. The excess glass beyond the maximum diameter of the deformed bulb is then cut with an abrasive wheel. If this head is properly made it will have a bell-shape and a diameter, across the bell opening, of 10 mm. Three 2-mm. beads are then formed on the edge of the bell orifice by fusing a small glass rod to the edge and cutting the rod with the burner flame. This glass is then fused until it forms a bead.

Two thin glass braces are fused to the pump in the position shown in Fig. 170. These braces should be long enough so that the pump can be centered in the inner jacket tube. After the proper lengths of the braces have been obtained by either pulling the partly-fused glass or cutting it with the burner flame, the pump is mounted in the inner jacket assembly and the braces are sealed to the glass wall.

3. Boiler

The boiler is made by first spinning a flare on 10-mm. tubing. This flare should fit over the end of the 22-mm. tubing of the inner jacket. The flared tube is then mounted at the flared end and the tube is closed by rounding the end 2 cm. from the flare. This closed end is then dipped into 50-mesh ground glass while it is hot and the ground glass adhering to the boiler is partly fused. The surface of the boiler is completely coated by repeating the dipping and fusing operation. The coated boiler is then sealed to the 22-mm. tubing of the inner jacket.

4. The inner jacket assembly is centered in the outer jacket with glass tape as illustrated in Fig. 171. The con-

Fig. 171

denser is made as illustrated in Fig. 170. The inner jacket is then ring-sealed to the outer jacket and the condenser is sealed to the apparatus. The seal is then annealed.

5. The outside jacket is drawn down and a 19-mm. tube is sealed to the reduced end.

6. The heating element assembly is made by sealing two press welds into the glass. This is accomplished by beading the cleaned tungsten sections of the press weld with GT-70 glass. (Techniques of beading and making the press seal have previously been given.) The press flare consists of a flare of Pyrex glass 774, a graded seal between this glass and the glass 772 of the press is made of uranium glass 3320. The nickel extension lines are welded to a spiral made from a 4′ length of 0.017″ diameter tungsten wire. The 19-mm. tube which is the extension of the outer jacket is then cut so that the heating element when placed into the jacket will be located in the boiler. The flare and jacket are sealed and a tubulation is sealed to the flare.

7. The jacket is evacuated and tipped off as previously described.

8. An Eby vacuum tube socket is cemented to the heater end and the two heater leads are soldered to the socket prongs. Fig. 172.

4. Thermometer

A well-constructed, finely-etched and properly-filled differential thermometer is essential for good results. It is important that the bore of the glass in the two arms be constant over the distance traversed by the meniscus, in order that the capillarity correction (zero reading) may remain constant during the experiment. The ordinary instruments purchased on the market are commonly defective in this respect. The liquid with which a thermometer is filled depends on the solvent with which it is to be used. Water, having a dp/dT of 14.3 mm./°C. at 80°C. makes an ideal filling for use with benzene or other solvent boiling within a few degrees of this temperature. When, for example, acetone is to be used as a solvent, ethyl alcohol (dp/dT, 14 mm./°C. at 56°C.) or benzene (dp/dT 1 mm./°C. at 56°C.) would be preferable as thermometer liquid.

The water-filled thermometer is made as follows:

1. A 15-cm. length of 2-mm. bore capillary is sealed to an 8-mm. thin-wall tube. The capillary is cut and blown open 12 cm. from the seal. A tube 8 mm. in diameter is sealed to the opened capillary. This tube is then constricted 3 cm. from the capillary-tube seal and a 6-mm. tube cm. long is sealed beyond the constriction to serve as the filling tube and eventually as the handle of the thermometer.

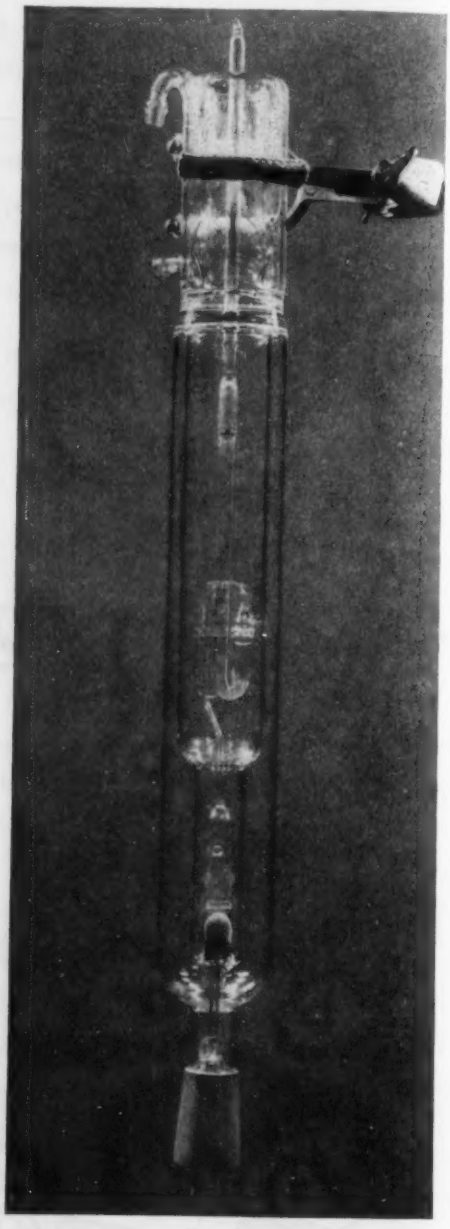

Fig. 172

2. The capillary adjacent the 8-mm thin-wall tubing is heated and a U bend is made as shown in Fig. 170. This bend is made so that the unaltered bore of the 8-mm. tube, adjacent the seal, is even with the unaltered bore of the capillary. The 8-mm. thin-wall tube is then closed so that 15 mm. of the original bore of this tube can be used for etching.

3. The thermometer is sealed to a water reservoir and the assembly is sealed to the manifold of a vacuum system, Fig. 173. The water level should be as indicated so that freezing will not break the bulb.

4. The vacuum pump is started and the system is pumped to 20 mm. pressure. The water is gently boiled by warming

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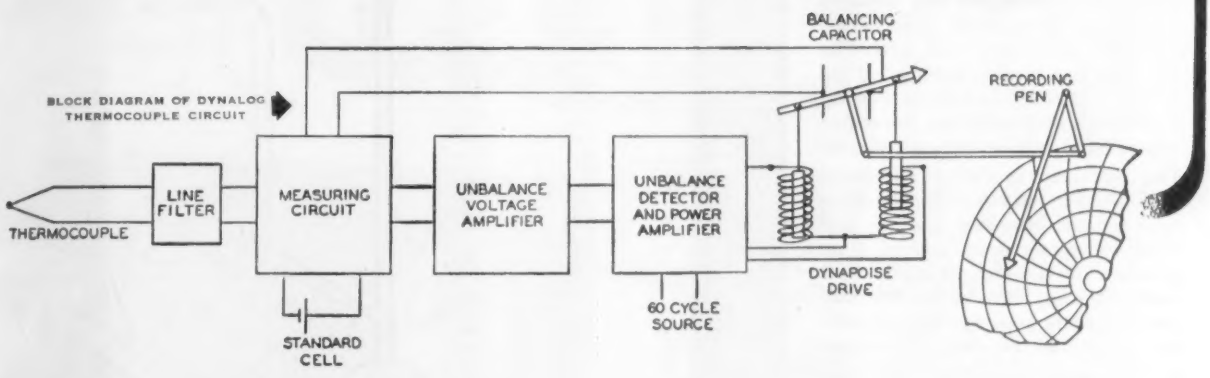

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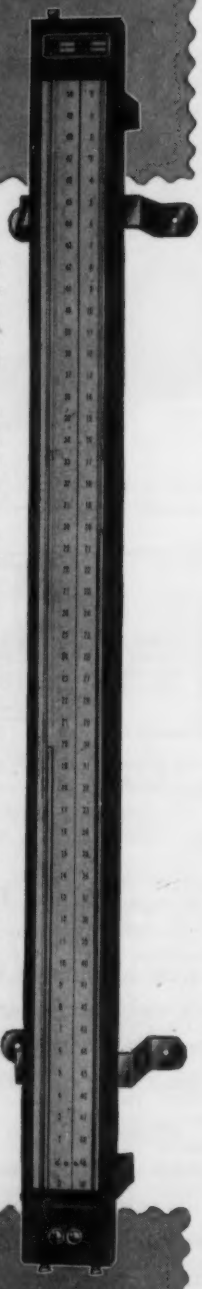

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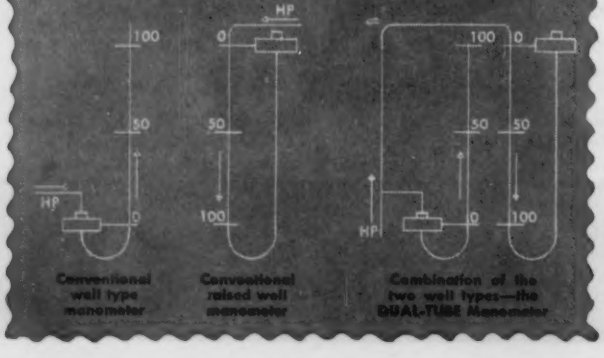


the bulb with a small flame. After the water is degassed by this process it is frozen with liquid nitrogen. The system is then pumped to a pressure of 10^{-5} mm. of mercury and the glass of the entire thermometer is carefully torched to remove gases. After the thermometer is outgassed and a pressure of 10^{-5} mm. is again obtained, the tubulation at *A* is tipped off. The ice is then melted and the water is allowed to flow into the thermometer bulb. This bulb and the capillary to *C*, Fig. 173, should be filled with water. The water storage bulb is then cooled and when the meniscus

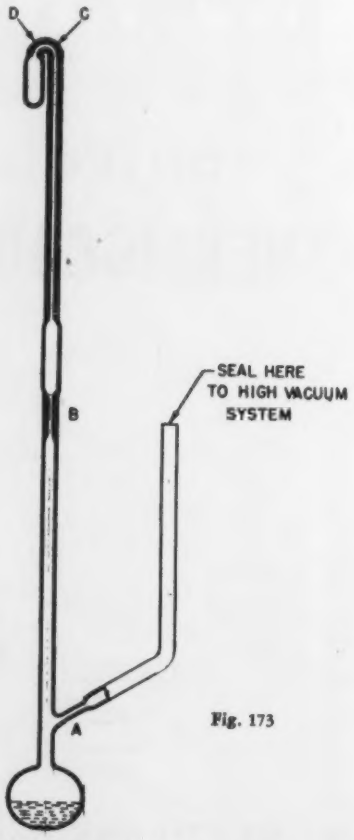


Fig. 173

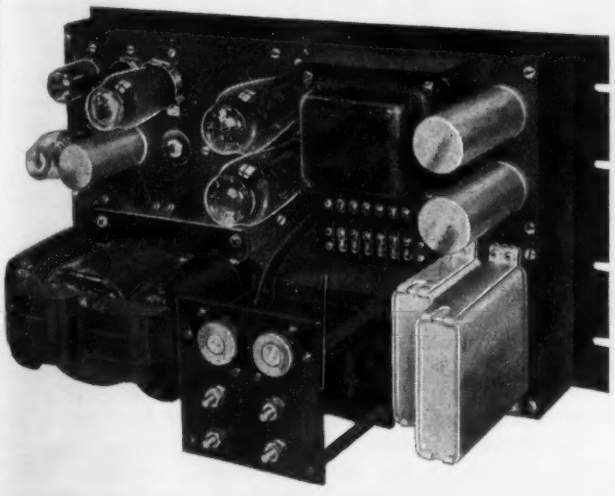
has retarded to *D*, Fig. 173 the constriction at *B* is quickly closed by fusing the glass around the circumference of this constriction. The water reservoir is removed and the 8-mm. tubing is closed. A glass eyelet is sealed at the closed end.

5. The thermometer is then ready to be etched. This operation can best be performed by companies which have accurate etching facilities. (Corning Glass Works, Corning, N. Y., have such facilities.) The zero mark on both the bulb and capillary should start at the lowest part of the bulb and capillary which have the true bore of the original tubes. Fifteen 1-mm. marks are made on the bulb. The capillary is etched up to 10 cm. in mm. divisions. The centimeter divisions on both scales are numbered.

The technique for filling thermometers with benzene or ethyl alcohol is different from that described for filling thermometers with water. The thermometer cannot be sealed as the meniscus is retarding in the capillary and carbonization will occur in the restriction while the glass is fused. It is necessary to cool both the reservoir and thermometer bulb and consequently the 6-mm. tubing between the restriction and reservoir must be bent in a U-shape so that both bulb and reservoir can be cooled simultaneously. The liquid and glass in the thermometer are degassed as described above. The thermometer is evacuated and the reservoir and thermometer assembly are tipped-off and the liquid is melted and allowed to flow into the thermometer bulb until the meniscus is at mark *D*. The bulb and reservoir are then cooled and the liquid in each is frozen without distilling any liquid to or from the capillary. The thermometer is then closed as before by fusing the glass at the restriction. The U-shaped tube is then cut from

no matter how we tell it

IT'S NEWS



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the thermometer and a straight section is sealed in place and the handle is made as before.

5. Power Supply

The power supply recommended is a Thordarson transformer, T-19F-99 (110-v. primary; 6.3-v. 10-amp. secondary). This instrument is put in series with a fixed resistor of 0.25 ohms (four I.R.C. "Type AB" 10-w. 1-ohm resistors in parallel) and a variable resistor (Ohmite "Type J" power rheostat, 0.5 ohms, 10 amp.). The circuit is fused for 10 amperes (secondary). Since the heating coil cannot be duplicated absolutely from instrument to instrument, the fixed resistor may have to be changed slightly. In general, it is believed that the suggested circuit is sufficiently flexible so that good boiling can be obtained in any apparatus simply by adjusting manually the power rheostat. The instrument operates at 8 to 9 amperes, with a power consumption of 25 to 30 watts.

Working Range of the Apparatus

Any apparatus which makes use of the ebullioscopic method is subject to limitations in molecular weights which it will handle. The lower limit is governed by the rule that the solute being investigated must have a negligible vapor pressure at the boiling point of the solvent. For the most common solvent, benzene, the lower limit may be perhaps 160 to 170, if the material is pure. In the case of a material like a petroleum oil, which contains a large number of compounds, the most volatile components present must be considered; as a result, it may be impossible to run materials of average molecular weight less than 200 to 250.

The upper limit in molecular weight is variable. Materials having as high a value as 1000-2000 have been run successfully; in special cases products of even higher average molecular weight have been analyzed with apparent success.

Selection and Purification of the Solvent

The first point to be considered is the selection of an appropriate solvent. Theoretically, almost any organic liquid* having a satisfactory ebullioscopic constant could be used. From a practical standpoint, the number of substances which can be employed is relatively small. This is a consequence of two requirements which the solvent must meet.

In the group benzene, cyclohexane and carbon tetrachloride, benzene is outstanding. Not only is it a versatile solvent, stable, and chemically inert, but is can be prepared in a high and consistently reproducible state of purity. For this reason, work in a laboratory has been done almost exclusively with this solvent. The particular advantage gained in the matter of purification will be evident in the following discussion.

Benzene in the "CXP" or, even better, in the "reagent" grade is one of the purest chemicals available today. Ebulliometric experiments have shown that it is impossible to purify such benzene further by any process of rectification. Improvement can be gained by cryoscopic means. Thus, by recrystallization, "CXP" benzene (F.P.—5.40°C.) can be

*Water is unsatisfactory. The instrument was designed primarily for organic solvents. The latent heat of water is so high that, even at maximum power input, the boiler cannot be maintained full of vapor.

(1) *Boiling Temperature.*—Obviously, a highly volatile or involatile solvent would not be suitable. The boiling range is even more restricted, however, because of the thermometer filling. As pointed out above, the water thermometer has the ideal sensitivity (dp/dT) at about 80°C. Above this point it increases, eventually becoming too sensitive for good operation; below it the temperature response is less and, ultimately, becomes too small to be practical.

Thus, benzene, cyclohexane, carbon tetrachloride, methyl ethyl ketone, isopropyl alcohol, etc., are satisfactory with respect to boiling temperature. Other solvents boiling at lower or higher temperatures are less desirable.

(2) *Purity of Solvent.*—To show the necessary low, steady zero point on the thermometer, a solvent must be pure. It is almost impossible to set a limit for allowable impurities, since this would depend in part on the accuracy desired in the results. It will suffice to say that, of the several solvents listed above, only benzene, cyclohexane, and carbon tetrachloride can be purified with ease.

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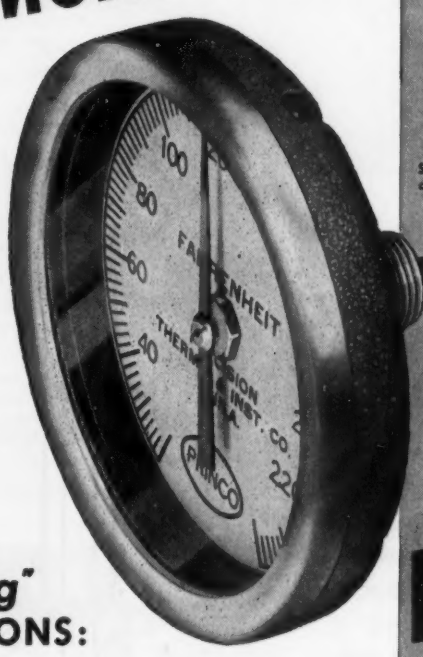

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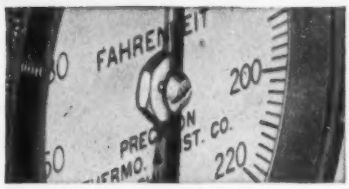

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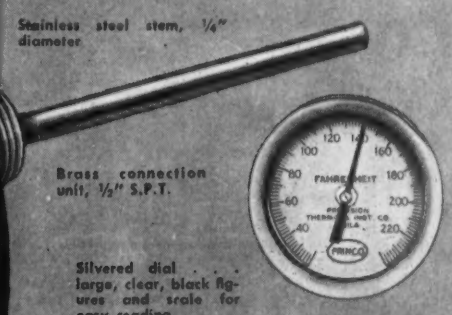
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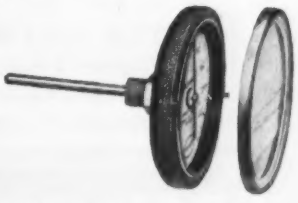

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raised to "reagent" grade (F.P.—5.50°C.). "Nitration" grade (F.P.—5.20°C.) is hardly to be recommended for molecular weight work. It is absolutely essential to remove the water, however, but, since the benzene-water azeotrope boils at 68°C., as against 80°C. for the pure benzene, only simple distillation is necessary to prepare it for use; a particular technique is required to be sure that this water removal is complete.

In the past, only imperfectly-dried benzene had been employed. Despite this, precisions of one percent or better were obtained, since the solvent was calibrated for the conditions under which it was being used. Complete removal of the water, however, has eliminated the most important of the remaining causes for irregularity and has resulted not only in an improvement of the precision by at least 0.5%

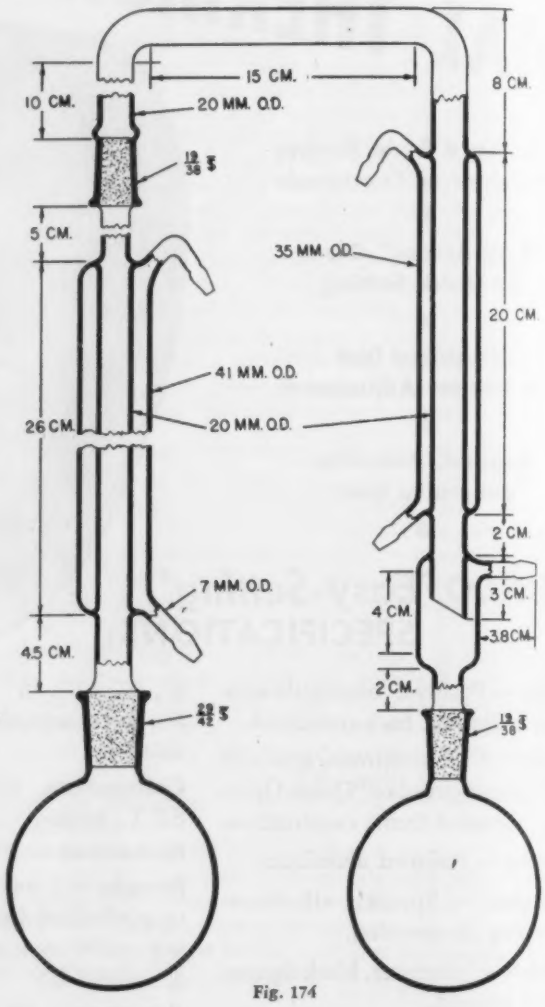

Fig. 174

but has made for a much smoother and more rapid determination.

A three-liter round-bottom flask is set up with a vertical water condenser attached to the flask through a ground glass joint, Fig. 174. (No grease!) The upper end of the condenser tube is bent through two right angles into an inverted U and connected through a ground glass joint to a second condenser parallel to the first. A receiver with a vent is attached to this second condenser through an appropriate joint.

Benzene is charged to the flask and heated to boiling; a Glas-Col heating mantle is recommended. Water is circulated through the two condensers. The water precipitating from the condensing azeotrope will be seen shortly as a milky band in the first condenser. When the water is thus sharply defined in this tube, the cooling water is withdrawn, allowing the condenser to become warm. The azeotrope now progresses slowly over to the second condenser where it

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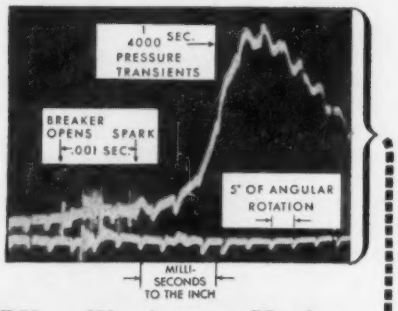

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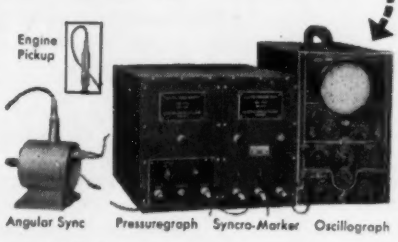

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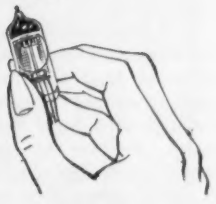

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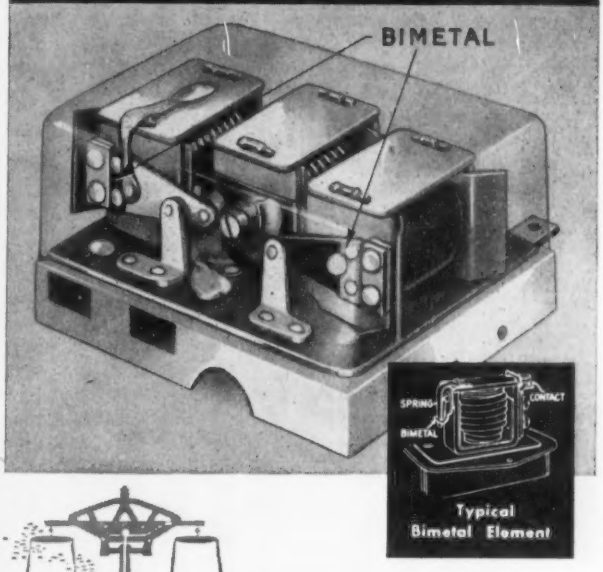
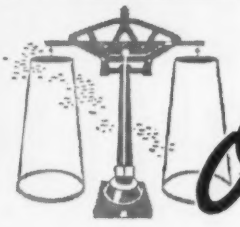
THERMOSTATIC BIMETAL





Ounce of Protection

Here's an interesting but little-known use of Chace Bimetal. Shown within a "phantom" case is "the works" of the Jubilee Manufacturing Company's three-unit type voltage regulator. You'll probably find one under the hood of your car. It works silently and without attention, regulating the flow from generator to battery, protecting both under fluctuating conditions.

Two small bimetal elements are indicated. The bimetal hinges automatically adjust the tension between the contact points to cause the regulator to operate at a lower voltage when hot and a higher voltage when cold, since a higher voltage is required to charge a cold battery.

This is a typical use of Chace Bimetal as the actuating element in a temperature responsive device. The dependability of their 35 types of bimetals has made the name "Chace" a byword with engineers concerned with the precise control of heat or cold.

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again can be seen as it passes on into the receiver. To clear this second condenser, the coolant is withdrawn and hot vapor allowed to pass through it briefly. A drying tube ($CaSO_4$ anhyd.) is attached quickly to the receiver vent and water turned into the second and then into the first condenser. If the water removal has not been complete, the line of condensation in the first condenser will still show signs of cloudiness.

When properly handled, this method allows for complete and controlled removal of the water in a sample of benzene. It should be noted that the same process cannot be carried out in an ordinary rectifying still, except under special conditions. This is a consequence of the manner in which the still heads are commonly constructed.

As soon as it has been determined that water removal is complete, the condensers are removed and replaced by a stopper (no grease!) having a tube through it which reaches to the bottom of the flask. The tube extends over in the form of an inverted U ending in a stopcock (no grease!) with a burette tip. By forcing dry air ($CaSO_4$ anhyd.) into the flask through a side tube in the stopper, dry benzene can be delivered when needed to the Bailey weighing burette as described below.

Calibration of the Thermometer

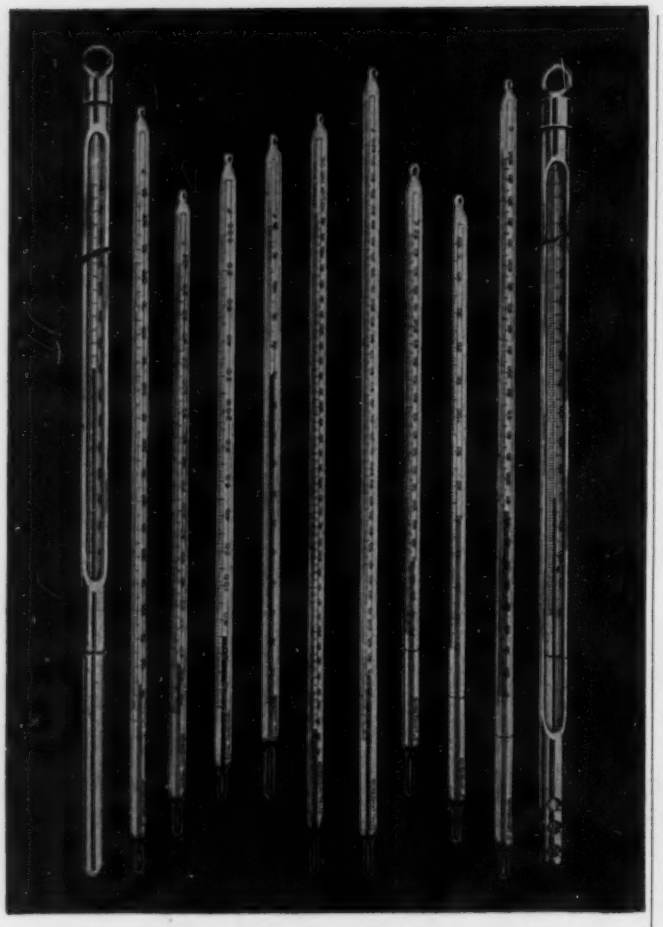
The clean and dry instrument is set up. In this calibration, as in every subsequent run, cleanliness is essential. The apparatus is washed with the same solvent which is being used in the molecular weight determinations (not the calibrated material, however) and the apparatus dried in a current of dry air until no remaining benzene is visible on the heating cone, in the pump, or at the ring seal at the base of the condenser. Experience has shown that the solvent clings to these places longest. If rinsing the equipment is not sufficient, boiling some of the solvent in the apparatus will remove any soluble material. In extreme cases, chromic acid or other cleaning agent may be used. Should water be present in the boiler, it is better that benzene be added and allowed to boil over the top of the condenser than to attempt to remove it by the use of some other solvent. The thermometer also should receive attention to be sure that no solute or other material adheres to it, particularly between the supporting ring and the glass stem.

A Bailey burette is filled with the purified benzene by injecting dry air into the three-liter storage flask as explained in the previous section. The benzene remaining in the stopcock and the tip of the tube should be discarded before withdrawing new solvent. About 25 grams (about 28 cc.) of the benzene is transferred to the apparatus; no weight is required for this thermometer calibration experiment.

The thermometer is now set in place, taking care that the vanes of the brass or bronze supporting ring are so adjusted that the instrument hangs vertically. Sufficient tension should be exerted by the vanes to hold the lower thermometer bulb firmly against the inverted cup of the pump. Failure to observe the latter precaution will invariably result in unsteady readings. A drying tube ($CaSO_4$ anhyd.) is placed in the top of the condenser and the coolant water turned on. It will be well to observe this sequence with respect to the condenser water to avoid exposing a cold inner surface to moist air during the addition of the benzene.

The temperature of the condenser water should be kept at 20°C. or below to assure a negligible loss of solvent. During warm days, it may be necessary to precool the tap water with ice; care should be taken, however, not to drop the temperature below the freezing point of the solvent. Under proper operating conditions, condensation is complete on the supporting ring and at the base of the condenser.

Heat is applied and the solvent allowed to boil for about a half hour. The rheostat is adjusted to a point where an intimate mixture of vapor and liquid is thrown over the bulb, and the vapor condensation line has reached the base of the condenser. Unless the instrument is filled with vapor, water remains in the upper bulb of the thermometer. The extremes in boiling, in which large slugs of solution or a



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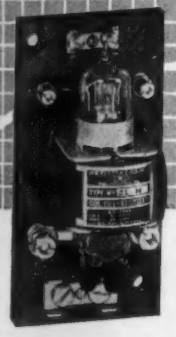

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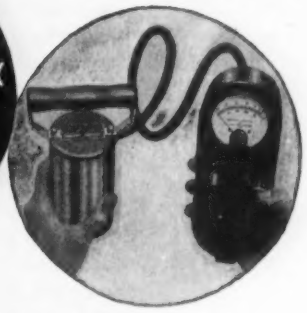

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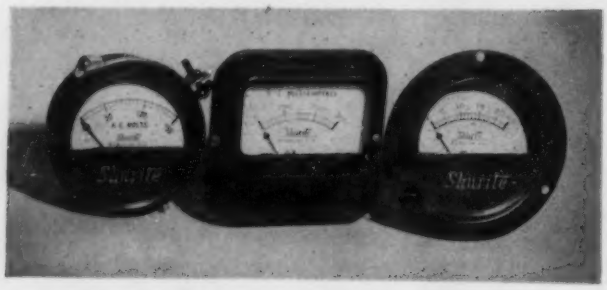

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stream of vapor is forced through the pump, are to be avoided. Actually, there will be a range in heat-input over which no change in thermometer reading as observed. Experience has shown that, even when a solute is present, the setting can be changed somewhat without altering the reading although, at higher rates of boiling more solvent is on the walls of the apparatus and, hence, the concentration and the boiling point are higher. Readings are now taken on the long and short arms of the thermometer; their difference is the zero value, or that proportion of the height of water which can be attributed to capillary effects. Strong light on either of the thermometer bulbs is to be avoided, except for the few moments required to take a reading.

Establishing the correct zero point is one of the most important operations. The value depends on four factors:

1. The boiling temperature.
2. Thermometer dimensions.
3. The liquid used for filling thermometer.
4. The purity of the solvent.

Since, for any given thermometer and solvent type, the first three factors are constant, the fourth item is the only one to be considered. If the thermometer were immersed in a thermostat at, say, 80°C., both bulbs would be at precisely the same temperature and the difference in level would be wholly dependent on the difference in the dimensions of the two arms. In the instrument, however, the upper bulb is at the condensing temperature of the solvent and, unless the material is absolutely pure, it will be slightly cooler than the lower bulb (boiling temperature). Thus, the zero correction is slightly greater than that due to capillarity.

This zero reading is the first check on the cleanliness of the apparatus and the purity of the solvent. Ebulliometric studies have shown that the difference in the boiling and condensation points for dehydrated "reagent" benzene is 0.008°C. and does not vary over 0.001°C. from this value. "Reagent" benzene, after removal of water in the manner described, will always give exactly the same zero reading for any given instrument and thermometer. If it varies by more than say 0.02 cm. (0.001°C.) on the water scale, contamination can be presumed. "CXP" benzene exhibits a boiling-condensation temperature difference of 0.010°C. to 0.015°C. depending on how much benzene is removed in azeotroping the water. If the procedure is carried out in about the same manner each time, duplicate batches of "CXP" benzene will have exactly the same zero, if the stock supply is the same. A new stock will yield purified material having a consistent zero but differing somewhat from the first. Our practice is to set aside five or ten gallons of stock benzene (CXP) and prepare two or three liter batches from this supply.

The advantage of this constant zero point will be seen in the calibration of the solvent. For any given instrument and thermometer, it has been shown that a new batch of benzene having the same zero as the old batch will have exactly the same ebullioscopic constant and, hence, need not be further calibrated.

For convenience in later runs it is important that the relationship between the readings obtained on the long arm and those on the short arm be determined. To do this a small amount of an involatile solute is added, enough to cause a rise of a few millimeters of water on the thermometer. Readings are now taken on both arms, according to the prescribed method. More solute is now added and the process continued, taking several readings over the entire thermometer scale. When the long-arm values are plotted against the short-arm values, the graph obtained should, for a well-constructed instrument, be perfectly linear. It is possible that slight curvature may be noted as one nears the zero point. As an aid in later calculations it will be found convenient to plot the long-arm reading against the net rise, the latter being calculated as the difference in the levels in the two arms minus the zero reading for the instrument. Thus, during any determination, a single reading on the long arm is sufficient to fix the net height of the water column. It may be mentioned that a value of Δh obtained from the graph is much more reliable than that obtained by the use of any single reading on the short arm,

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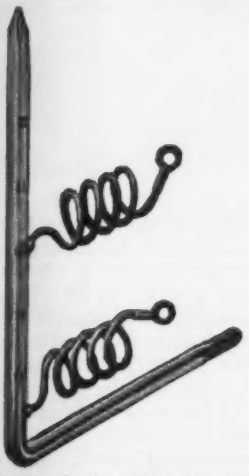

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since short arm readings are, in general, difficult to get exactly.

Calibration of the Solvent

Calibration of the solvent to be used is essential as the commonly published ebullioscopic constants are not applicable. The chief reason for this is that the actual amount of the solvent in the liquid phase, and hence the absolute concentration, is not known. Since very nearly the same amount of benzene is used each time, since the boiling rate is the same, and since the vapor condenses totally at the base of the condenser, a constant fraction of the solvent is removed from the liquid phase and this factor enters into the K which one determines by running a compound of known molecular weight.

Any compound which may be purified easily and which possesses a reasonable solubility in the solvent being used will serve as a calibrating compound. In general it is believed that compounds should be used which are of similar chemical type to those which are to be examined later. Particularly to be avoided are those compounds which are polar in nature, as these materials frequently exhibit a molecular weight-concentration slope. The necessary extrapolation of the apparent K value to zero concentration is a possible source of error and hence is to be avoided. Experience in this laboratory has shown that triphenyl methane, meta-diphenyl benzene, anthracene, and benzil are especially satisfactory as standards. Regardless of the purification process used for any particular compound, it is advised that the final step be a recrystallization from the solvent to be employed in the molecular weight determinations, followed by a drying of the powdered material in high vacuum. The retention by the crystals of a volatile substance other than the solvent being used in the molecular weight determination may introduce a large error. Before use, it is convenient to form the purified crystals into pellets, each of about 0.2 g. Materials so purified can be kept almost indefinitely.

Into the clean and dry instrument there is now weighed by means of the Bailey burette about 25 grams (28 cc.) of the purified solvent, care being taken in the withdrawal and transfer as previously described. The Bailey burette is particularly recommended for cutting evaporation losses and avoiding exposure of the solvent to moist air. The thermometer is inserted, the drying tube ($CaSO_4$ anhyd.) placed at the top of the condenser, and the coolant water turned on.

Heating is now begun and the solvent allowed to boil for about twenty minutes. By this time the apparatus has been brought to temperature and the thermometer should have attained a steady reading. The zero point may now be checked. While the apparatus is coming to temperature, about a gram of the purified solute is placed on a watch glass and weighed to the nearest 0.1 mg. At the end of the 20-min. period, or as soon as the zero point has been checked, the drying tube is taken from the top of the condenser and small pellets of the solute added, taking care that none strikes the condenser wall or lodges in the ring supporting the thermometer. This process becomes easy after a little practice. As soon as the addition has been made, the drying tube is replaced and the watch glass containing the solute weighed again in preparation for the next addition. Under normal conditions, the solute dissolves almost immediately and a reliable temperature reading can be made at the end of five minutes. Occasionally, during an actual molecular weight determination, additions of several tenths of a gram of solute is necessary (high molecular weight compounds). The thermal disturbance resulting from the addition of such an amount of cold solute may be so great that more than five minutes will be required for the apparatus to come to equilibrium. A steady thermometer reading is, of course, the criterion. A second portion of solute is now added and the process repeated until in all four or five additions have been made. At some time during the run the pressure (corrected to 0°C.) should be taken; unless the run is unduly prolonged, this one reading will suffice for the determination. In general the run should not last over one and a half to two hours, not only for

STATHAM
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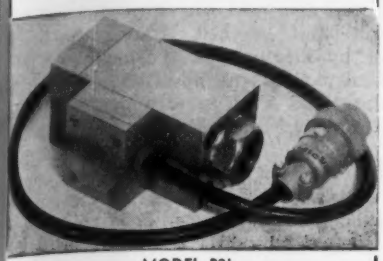

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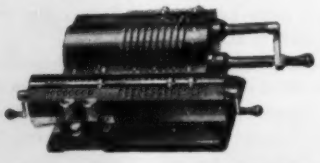

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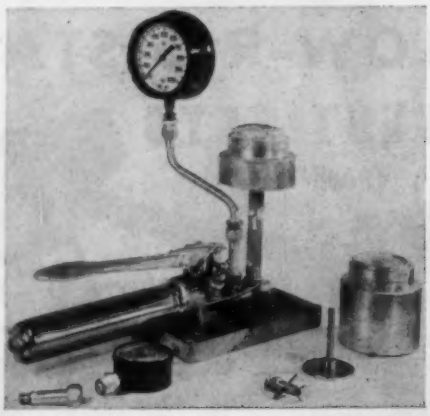

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reasons of changing pressure but also for the sake of convenience. Loss of solvent under these circumstances is, of course, less.

For liquids, a small vial equipped with an eye-dropper is filled with the material and weighed. Adding the liquid through the condenser by means of the eye-dropper presents no greater difficulty than the addition of the solid pellets as previously described. Vial, eye-dropper, and liquid are weighed again after the addition. For liquids which are sufficiently involatile to be run in this apparatus, no evaporation losses are observed. In cleaning the eye-dropper, care must be taken that the solvent used for cleaning is not absorbed by the rubber bulb. This has been observed to happen particularly when benzene is employed, with the result that the eye-dropper slowly loses weight over a period of time as the solvent evaporates.

The usual formula for calculating the ebullioscopic constant applies.

$$K_b = \frac{\text{Mol. wt. of solute} \times \text{wt. solvent} \times \Delta t}{\text{Wt. of solute} \times 100} \qquad (38)$$

Here Δt is the rise in the boiling point in centigrade degrees and K_b the constant in centigrade degrees rise in boiling point per mole of dissolved solute per 100 g. solvent.

Tables are given by Menzies[3] for converting the reading obtained on the water thermometer (cm. H_2O) to centigrade degrees, but the process is too laborious to be used in routine work. The following procedure is to be preferred.

Calculate values for the constant for each addition of solute in each run using, instead of Δt in centigrade degrees, the value in centimeters of water; this will be the long-arm reading on the thermometer minus the short-arm value (obtained from the prepared chart), minus the zero point. A series of figures, referred to as K_{H_2O} values, will be obtained. These values are a function of the barometric pressure and the temperature. Assuming benzene to boil at 80.110°C.[4], the following table of factors has been prepared for converting K_{H_2O} values to the pressure- and temperature-independent absolute constants (K_b).

	mm. Hg Pressure			
Δt (cm. H_2O)	750	740	730	720
0	1.991	1.962	1.933	1.904
5.0	2.009	1.979	1.950	1.921
10.0	2.026	1.996	1.968	1.939

The constants so obtained may be averaged and the mean deviation should not exceed ± 0.5%.

Once the value of the absolute constant has been determined, a table can be constructed, again by use of the factors, giving K_{H_2O} as a function of pressure and Δt. For illustration two typical calibration runs are cited together with the necessary calculations.

Instrument #2 — Solute: m-Terphenyl, M.W. 230.29
Thermometer A — Benzene (*batch* #2) 26.377 gms.
Thermometer zero 0.73 ± 0.01 cm. H_2O — P = 731 mm. (corr.)
Cumulative wt.

Solute, gms.	Δt cm. H_2O	K_{H_2O}
0.3330	4.44 − 0.79 − 0.73 = 2.92	53.40
0.4381	5.27 − 0.67 − 0.73 = 3.87	53.65
0.5357	6.02 − 0.57 − 0.73 = 4.72	53.50
0.5993	6.50 − 0.50 − 0.73 = 5.27	53.40
0.6822	7.15 − 0.41 − 0.73 = 6.01	53.50
0.7517	7.67 − 0.33 − 0.73 = 6.61	53.40

Using appropriate factors,

53.40/1.946 = 27.45	53.50/1.952 = 27.40
53.65/1.949 = 27.52	53.40/1.954 = 27.34
53.50/1.957 = 27.34	53.40/1.959 = 27.28

Av. K_b = 27.39 ± 0.07

It will be observed that we are working on the border line of our limits in precision. Thus, it would have done just as well in this case to have averaged the K_{H_2O} values and divided by an average value for the conversion factor (Δt = 5.0), thereby neglecting the dependence of the factor on Δt. In some cases, however, such as the last illustration in the next section, where a fair range in Δt is covered and, particularly, where there is a molecular weight-concentration slope, the error is not negligible.

Having found the average K_b value to be 27.39 ± 0.07 we

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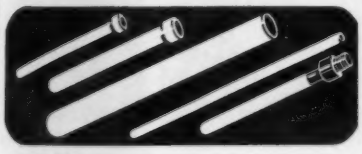

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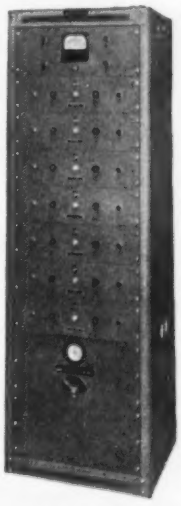
This instrument is completely described in Technical Bulletin 1142, a copy of which may be obtained on request.



Multipoint Alarm System control cabinet used in solution of this problem. Analysing Heads not shown.

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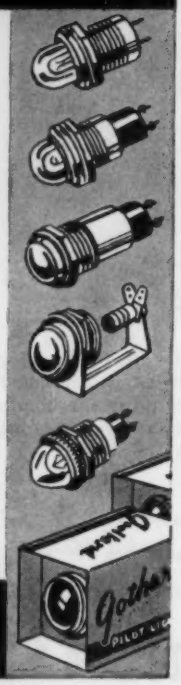

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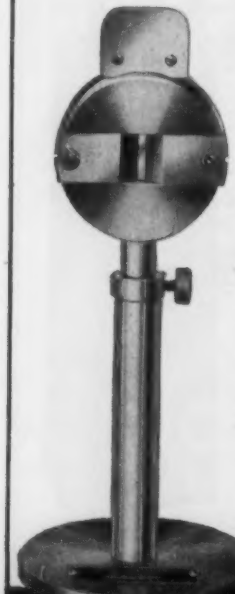

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*Vandaveer, *Industrial & Engineering Chemistry*, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

can construct a chart for use in subsequent molecular weight determinations from which the proper value for K_{H_2O} for this instrument, thermometer, and solvent can be picked off, knowing the pressure and Δt. Thus for $P = 740$ mm.

Δt cm.	K_{H_2O} (740)
0.0	$27.39 \times 1.962 = 53.74$
0.5	$27.39 \times 1.979 = 54.21$
1.0	$27.39 \times 1.996 = 54.62$

The process is repeated for other pressures and isobars drawn on Δt, K_{H_2O} coördinates at intervals of one millimeter. The plots are linear and calculation for each 10 mm. and dividing off the intervening space into ten parts is sufficient.

To illustrate the fact that a second batch of benzene from the same stock will have the same ebullioscopic constant if the zero point is the same, the following is quoted.

Instrument #2 — Solute: m-Terphenyl, M.W. 230.29
Thermometer A — Benzene (*batch* #3) 26.912 gms.
Thermometer zero 0.72 ± 0.01 — $P = 725$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	Calc'd. K_{H_2O}	Factor	K_b
0.4785	4.06	52.60	1.933	27.21
0.5521	4.70	52.77	1.935	27.27
0.6185	5.27	52.78	1.937	27.29

Av. $K_b = 27.26 \pm 0.03$

Therefore, if succeeding batches of benzene, with the same instrument and thermometer, show the same zero point, the same ebullioscopic constant may be used. If a different zero is observed, which cannot be brought to the old value by further removal of water or cleaning the apparatus, a new calibration must be run. A check run with a compound of known molecular weight is occasionally made for checking one's own technique, even though the zero point of the solvent has not changed appreciably.

Determination of a Molecular Weight

For determining a molecular weight on an unknown substance, exactly the same procedure is used as for the solvent calibration runs, except that the unknown is added instead of the calibration compound. A few typical runs are cited here to show, in one case, the accuracy and, in others, the precision which is possible to attain. The oils are highly refined, stable paraffinic petroleum products which were selected for molecular weight standards.

Instrument #2 — Solute: Triphenyl Methane
Thermometer A — Benzene (*batch* #2) 26.147 gms.
Thermometer Zero 0.70 ± 0.01 — $P = 726$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
0.3609	2.98	52.88	245.0
0.4294	3.57	52.94	243.5
0.5090	4.24	53.01	243.4
0.6199	5.15	53.09	244.3
0.7235	5.99	53.17	245.3

Av. Mol. Wt. $= 244.3 \pm 0.7$

Thus, using the benzene calibrated against purified m-terphenyl, a value for triphenyl methane is obtained which compares favorably with the theoretical value of 244.32.

A run was made on Molecular Weight Standard GA.

Instrument #1 — Solute: Molecular Weight Standard GA.
Thermometer #3 — Benzene (*batch* #1) 26.830 gms.
Thermometer zero 1.38 ± 0.02 — $P = 746$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
0.4449	2.99	53.92	299.0
0.6200	4.19	54.22	298.5
0.7900	5.36	54.35	299.0

Av. Mol. Wt. $= 299.0 \pm 0.2$

Repeating this oil with a different instrument, different thermometer and different benzene, we get the following:

Instrument #2 — Solute: Molecular Weight Standard GA
Thermometer A — Benzene (*batch* #2) 26.206 gms.
Thermometer zero 0.73 ± 0.02 — $P = 731$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
0.5324	3.67	53.35	295.5
0.7940	5.47	53.52	299.0
1.0466	7.15	53.67	296.5
1.2782	8.70	53.80	301.5

Av. Mol. Wt. $= 298.0 \pm 2.0$

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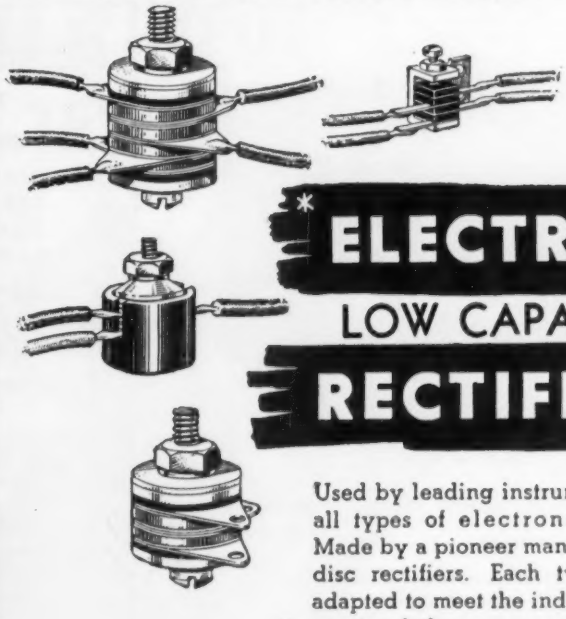

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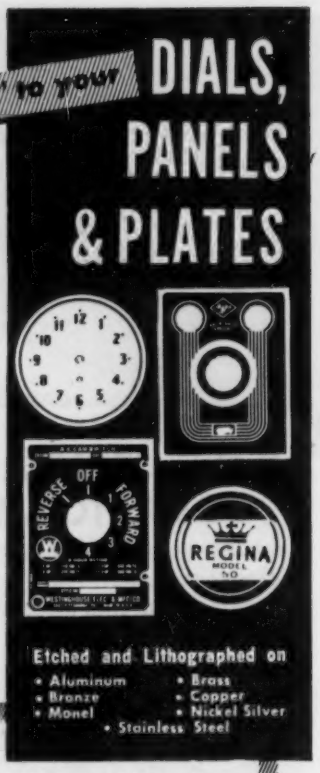

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Instrument #2 — Solute: Molecular Weight Standard CB
Thermometer A — Benzene (*batch #1*) 26.309 gms.
Thermometer zero 0.82 ± 0.02 — $P = 736$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
1.1064	3.63	54.18	630
1.3092	4.30	54.25	628
1.7393	5.67	54.37	633
1.9623	6.50	54.46	624

Av. Mol. Wt. $= 629 \pm 2$

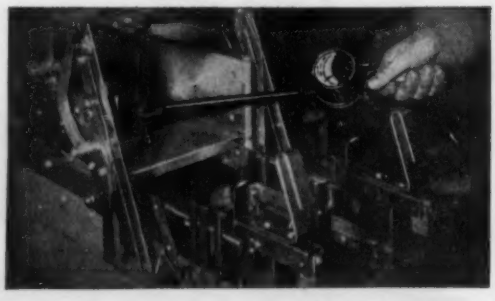
Instrument #2 — Solute: Molecular Weight Standard CB
Thermometer A — Benzene (*batch #2*) 25.412 gms.
Thermometer zero 0.71 ± 0.02 — $P = 732$ mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
0.8644	2.88	53.36	630.5
1.2031	4.03	53.47	627.0
1.4804	4.97	53.55	627.5
1.7399	5.89	53.63	625.5

Av. Mol. Wt. $= 627.6 \pm 1.4$

In the large majority of cases, the several values for the molecular weight obtained in a single determination may be averaged arithmetically as was done in the above illustrations. Occasionally, however, it is observed that the molecular weight value does change with concentration and the slope of the molecular weight-concentration curve may be positive or negative. The positive case is rare; it is observed for polar compounds such as acids and even a few light oils. Presumably, the effect is one of association in solution. Among high-molecular-weight materials, a negative slope is frequently encountered. The explanation is unknown but the effect is well established. Certainly in such large mass concentrations as are necessary for these materials to get the desired temperature rise, the solution is far from ideal and it is hardly to be expected that the simple law could be used for calculating the molecular weight without error.

In either case, an attempt is made to obtain the correct



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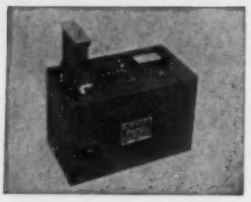

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value for the molecular weight by extrapolation to zero concentration of solute. For want of a better method, the best straight line is drawn and the error involved will depend on how closely the data conform to the linear relationship. Agreement among check determinations may be within one percent, although one cannot claim that this will be true under all circumstances. The following are check runs on our Molecular Weight Standard R which exhibits a definite negative molecular weight-concentration slope.

Instrument #2 — Solute: Molecular Weight Standard R
Thermometer A — Benzene (*batch #3*) 24.206 gms.
Thermometer zero 0.73 ± 0.02 — P = 734 mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
2.7490	3.58	53.60	1513
3.0280	4.01	53.63	1487
3.4660	4.70	53.69	1454
3.8665	5.36	53.76	1425
4.3026	6.07	53.81	1402
4.7434	6.87	53.88	1368

Extrap. Mol. Wt. = 1637 ± 10

Using a different batch of benzene a check run was made

Instrument #2 — Solute: Molecular Weight Standard R
Thermometer A — Benzene (*batch #3*) 27.340 gms.
Thermometer zero 0.73 ± 0.02 — P = 736 mm. (corr.)

Cumulative Wt. Solute, gms.	Δt cm. H_2O	K_{H_2O}	Mol. Wt.
3.079	4.08	53.96	1488
3.366	4.55	54.00	1460
3.797	5.20	54.05	1440
4.240	5.96	54.12	1407
4.610	6.61	54.17	1383

Extrap. Mol. Wt. = 1640 ± 10

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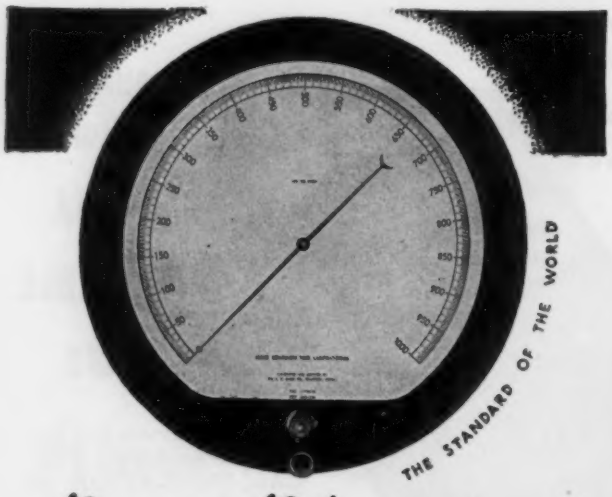

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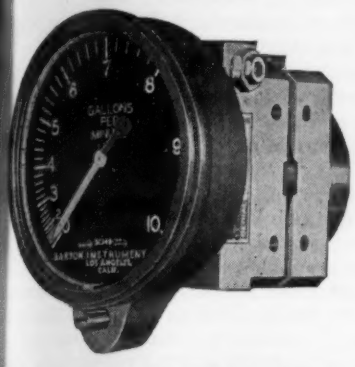

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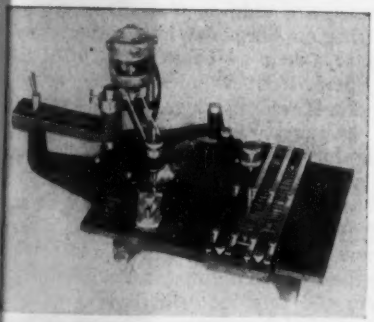

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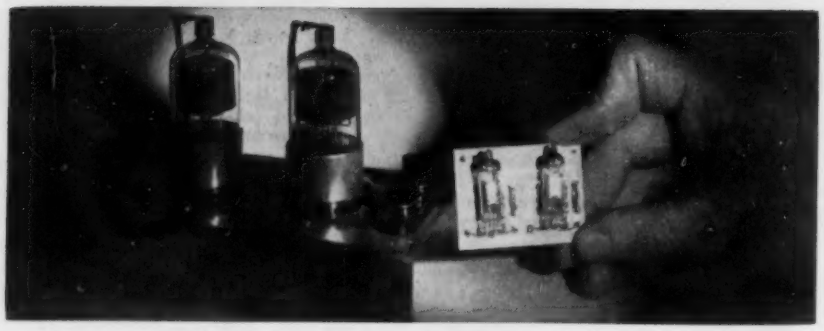
INSTRUMENTS ON THE MARCH

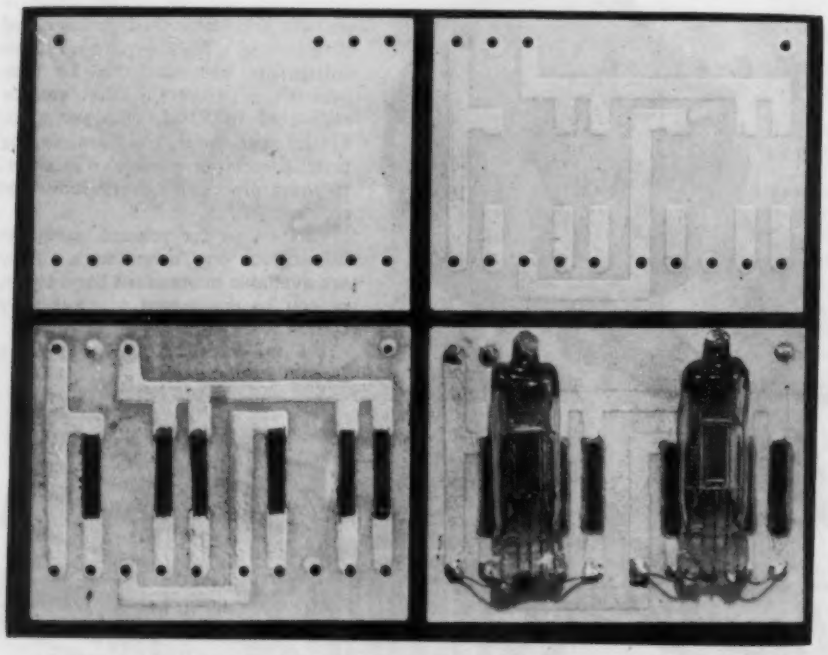


Size comparison between a two-stage amplifier constructed according to conventional practice and a miniature amplifier developed by the National Bureau of Standards for use with subminiature tubes.

Printing Electric Circuits

WASHINGTON, D. C.—The printed electric circuit, representing the perfection of a method of printing wiring and circuit components on an insulated surface, is one of the most important of the new processes and techniques evolving from research and development during the war. The new techniques, developed by the National Bureau of Standards in coöperation with electrical manufacturers for the tiny generator-powered radio proximity fuze, promise to simplify production methods and to accelerate the manufacture of cheaper, more compact and more uniform electrical equipment, according to Cledo Brunetti and Philip J. Franklin of the National Bureau of Standards.

The methods are applicable in the design of numerous industrial and commercial devices where extreme ruggedness and small size are imperative. By means of the printing process the circuit of a conventional radio—now characterized by a maze of wires, resistors, inductors and capacitors—may be replaced by a compact circuit printed on a small flat plate, eliminating much of the third dimension and making it simple to check and repair. Other specific applications cited by Messrs. Brunetti and Franklin lie in the fields of pocket radios, personal radio telephones, miniature hearing aids, meteorological instruments, and various miniature electric control circuits.



Four successive steps in making a printed circuit: a steatite plate after firing and shrinkage (upper left), plate with circuit wiring (upper right) and with the addition of resistors (lower left), and finally the assembled unit with miniature tubes (lower right).

Investigations at the National Bureau of Standards of methods for reducing assembly size and for mechanization of chassis wiring reveal a number of feasible and practical circuit-printing methods. Variations of the stenciled-screen printing process include hand printing or spraying of the electrical components and leads on suitable surfaces. Another method involves the use of photography and an abrasive blast. A third is an adaptation of the chemical methods of silvering mirrors. Mechanical processes include metal spraying, metal sputtering or evaporation, the use of foils, and stamping. As an example, loop antennas are now stamped out in a single operation by a variation of the printed wiring techniques and have shown improved performance over wire-wound loops in addition to reduced cost of production. The principal effect of these methods is to reduce electric circuit wiring to two dimensions. The effect is enhanced where it is possible to employ subminiature tubes and compact associated components.

Four simple techniques are the key to the circuit printing process which led to the design of control circuits capable of meeting the space limitation and ruggedness requirements of the VT fuze. First, the circuit wiring and inductors are painted or stencilled with silver paint on a chassis or base material, such as a plate of steatite. Second, the resistors, in the form of a carbon and resin mixture, are stencilled or sprayed on the plate through masks that locate them accurately between designated end tabs. The small disk type capacitors, of high-dielectric ceramic, are then applied directly to the wiring on the plate. Last, other components (such as tubes) are fitted into properly-located holes in the ceramic and soldered in place. In this manner, a compact circuit assembly, readily adaptable to high production techniques, is obtained.

Any insulating surface may be employed as a base plate for the wiring. Thus, electronic circuits may be printed on glass, porcelain, plastics, cloth, paper, and any material having suitable insulating properties. Steatite, a hard and dense ceramic material, is well adapted for use as a base material. Its hardness approaches that of sapphire; it is unaffected by water, solvents, or even acids—important factors in its electrical use.

The next step in printing the circuit is to apply a pattern of silver lines to the ceramic, either directly with a brush or by using a silk or metal stencil. The stencil is laid over a clean ceramic plate and silver ink is brushed over it. An impression on the plate exactly like the circuit wiring is thus obtained, in silver lines. The silver paint consists of very finely divided silver or silver oxide

mixed with a binder to make a paste and thinned with a solvent such as acetone. After impression of the pattern, the plate is heated to between 1300°F. and 1500°F., bonding the silver permanently to the ceramic. (Paints have been developed which require firing at considerably lower temperatures if desired. The principal advantage of higher-temperature firing is exceedingly strong adhesion to the plate.)

The resistors are sprayed or painted through another stencil, or brushed on. The resistor paint consists of a conducting material such as powdered graphite, and an inert or non-conducting material such as mineralite or powdered mica, mixed with a binder to form a paste or heavy ink. The resistivity may be varied by varying the amount of inert filler; the resistance value may be varied by suitably selecting the length, width, and thickness. After the resistor paint has been applied, the plate is placed in an oven at 300°F. to cure the resistors so that their values will not change with use. A special resin coating is painted over the resistors to protect them against humidity and other effects.

High-dielectric capacitors are then soldered in their proper positions on the ceramic with low-temperature solder. For ordinary radio and electronic application, the capacitors are from ⅛" to ⅜" in diameter and less than 0.04" thick. The new subminiature vacuum tubes complete the miniature subassembly.

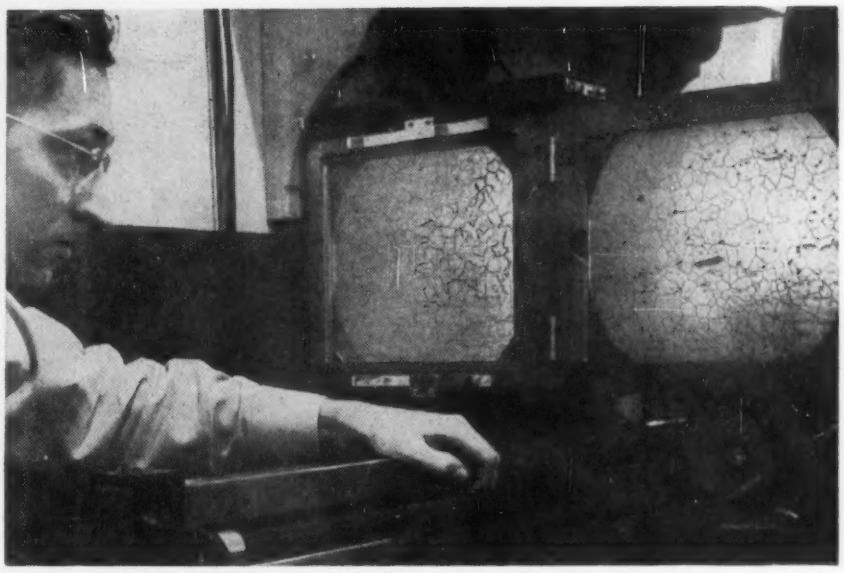
Uniformity of production, reduction of assembly and inspection time and reduction of line rejects make the circuit-printing processes industrially attractive because large reductions in cost are possible. Other important advantages include size reduction unobtainable by other means.

Betatron Research in Multimillion-volt Range

WASHINGTON, D. C.—Plans have been completed at the National Bureau of Standards for the erection of two betatrons, enabling scientists here to extend research, measurements, and standards development into the 50- and 100-million volt range.

Two immediate problems calling for extensive investigation are the determination of measurement techniques and the formulation of precautionary principles in the use of the betatron for cancer treatment.

For the past twenty years, the National Bureau of Standards has played a central role in the development of standards for x-ray dosage measurement and protection. The field has been covered thus far only up to one and a half million volts. For this purpose, the Bureau now has one of the best equipped x-ray laboratories in the world.



Measuring Grain Size of Alloys

PITTSBURGH, Penna.—A contribution to the search for better metals and by-products of his metallurgical studies is the new grain size comparator developed by F. C. Hull of the Westinghouse Research Laboratories. Consisting of a ground-glass screen hinged to an illuminating unit with a slotted frame, it is easily attached to a standard metallograph. It provides for counting the grains in a certain area or estimating their extent by comparison with a series of standard photographs. To determine the grain size of a particular specimen, a polished and etched sample is placed on the stage of the metallograph and projected in magnified form on the glass screen. A transparent slide of a known, standard grain structure is slipped into the adjacent frame and illuminated by incandescent light. The magnifying power of the metallograph is then changed by extending the bellows until the unknown image matches the grain size of the standard. The amount of adjustment needed is read from a scale on the metallograph, and grain size of the unknown specimen determined by reference to a standard graph.

CONTROL TOWER CONSOLE. Close-up view of Control Tower Console CY-422, one of the latest AAF developments designed to further air safety. The console is now undergoing field tests at Langley Field, Va., under the supervision of technicians from the Watson Laboratories. *(Army Air Forces Photo)*

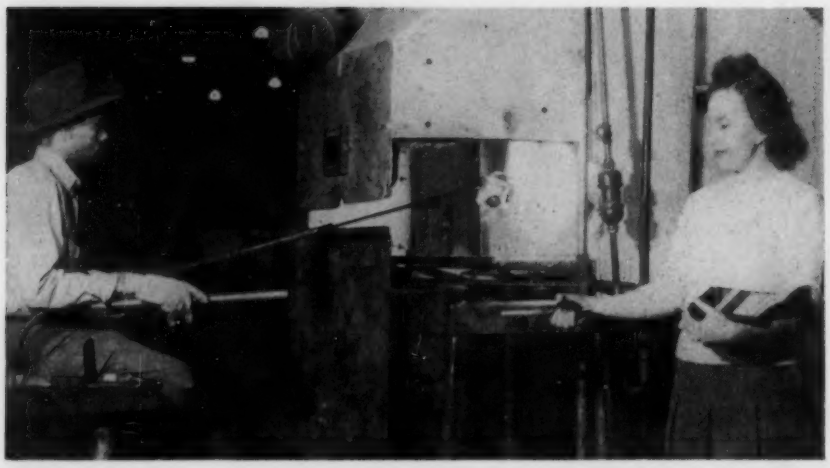


Fig. 1

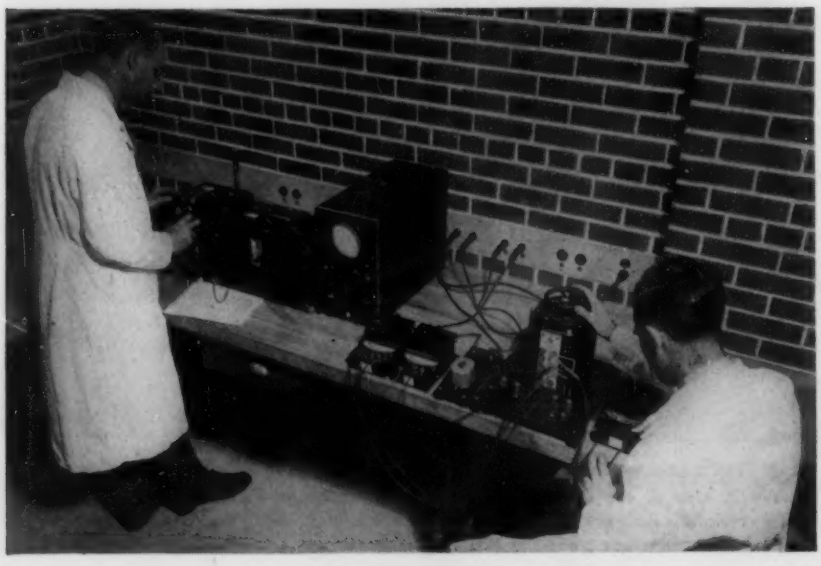
Fig. 2

No CO Danger at NBS

In our December 1946 issue, pages 732-733, there was described (without illustrations) the National Bureau of Standards' Colorimetric Carbon Monoxide Indicator which detects one part of CO in five hundred million parts of air. More than half a million of these NBS instruments had been supplied to the Armed Forces, but the NBS evidently kept at least one for its own use —as is evident from these two photos just received: In Fig. 1, Mrs. Marthada Kilday is shown testing for CO near the Bureaus glass-molding gas furnace; in Fig. 2 Mrs. Kilday is taking a sample of the air near a running engine in the Bureau's Engine Testing Laboratory.

Sound-analysis in Product Inspection

DES PLAINES, Ill.—In Benjamin Electric Mfg. Co.'s Product Development and Testing Laboratory, an acoustical room with sound-absorbing walls and ceiling helps to measure sound frequencies and analyze sound source. Motor-driven signals, coding sirens, fire-alarm howlers, mine type howlers and industrial buzzers manufactured by the company, are placed directly in the acoustical room (not shown in photo). Measurements of the sound emitted are made by instruments placed on an *exterior* test bench (shown in photo), thereby eliminating possibility of error resulting from foreign vibrations and sounds. Laboratory technicians are shown making an acoustical analysis of a signaling device emitting a complex sound. The sound produced by the signal is picked up by a microphone, and various characteristics of the sound are interpreted by means of a sound level meter, a frequency analyzer, and an oscilloscope.



The sound level meter is utilized to measure the total sound, while the frequency analyzer is used to analyze the sound by separating the various frequencies produced by the device undergoing test; enabling the technician to determine the dominant frequency and to determine minor frequencies in order of their importance. An oscilloscope gives a visual view of the component frequencies as they are segregated by the frequency analyzer.

As accurate electrical control is necessary for the device being tested, a technician utilizes regulated voltages, from the main laboratory switchboard, and with the use of an auto-transformer adjusts the regulated voltages to meet the various voltage requirements for the specific test. A voltmeter is placed in the circuit of the device being tested; an ammeter and a wattmeter are employed to observe the power consumption characteristics of the device being tested.

Special Chemical Keeps Rotameter-tube Surface Transparent

PITTSFIELD, MASS.—Use of G-E "Dri-Film" water-repellent material on area-type flow-meter glass windows has resulted in improved visibility and reduction of maintenance requirements, General Electric Chemical Department engineers have announced. G. E. stated that recent tests revealed that 100,000 gallons of crude oil, passing through a meter in a ten-day period, failed to affect the treated glass surface. This is in contrast to weekly cleaning operations on the untreated surface, they said.

Yale-GE Joint Research on Guided-missile Controls

SCHENECTADY, N. Y.—To permit ground testing of guided-missile controls, a Flight Simulator (dummy rocket for duplicating flight characteristics of a rocket missile) is under development as part of General Electric's long-range rocket research program, according to announcement by Ray Stearns, manager of the company's Aeronautics and Marine Engineering Division.

The simulator will couple an intricate calculating machine with a mechanical arrangement of gymbals driven by servomechanisms. When completed, the guiding equipment to be used in new

TUBING TAMES A TUNNEL PROBLEM

Penflex "Flexineering" solves air transmission problem on new Battery-to-Brooklyn tunnel project

Far out in the East River an island is growing. It's "man-made" for the Battery-to-Brooklyn tunnel project . . . and presents many construction problems. One was transmitting compressed air from a nearby floating unit of compressors, over the water, and on to the island for powering pneumatic tools used in construction operations.

That's where Penflex Engineers went to work. Ordinary air lines would not stand the pressure. Rigid pipes were not practical due to constant motion of the river. Result? "Flexineering" presented the right answer by specifying Penflex Tubing from compressor unit to the main air lines. Plenty of motion . . . plenty of pressure . . . yet entire job is safe and working steadily under all conditions.

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types of rockets can be attached and tested in the same maneuvers through which the rocket will be directed when actually launched.

In addition, research on controls for the simulator is being conducted by the Dunham Laboratory of Electrical Engineering at Yale University in conjunction with the G-E program, Mr. Stearns said. The project at Yale, under the direction of John L. Bower, Assistant Professor of Electrical Engineering, will be complicated by the fact that the necessarily compact design of a rocket missile and the tremendous forces acting upon it in flight, which may amount to millions of horsepower, require controls which are exceedingly rapid in their response. This in turn, makes necessary even higher performances in the testing equipment. The characteristically complex motion of the missile when traveling at supersonic velocities has made it essential to improvise and develop new devices for making the desired determinations.

The research will be concentrated on testing the complicated control devices which keep guided missiles on their course by manipulating the vanes that direct the flow of escaping jet gases from the missile in its flight.

This research will permit observations and adjustments of the control devices during conditions corresponding to flight and will aid in perfecting the design of missile controls. In addition, the techniques under investigation will permit a final check on each missile before the actual launching, thus preventing misfires.

Tube-testing Instruments

This engineer appreciates his "slip-stick" when he checks the characteristics of a 892R transmitting tube at the Brooklyn

plant of Amperex Electronic Corp. Large-dial instruments permit high accuracy in measuring current and voltage data on filament, plate and grid. Historical record of each tube is kept in the ledger for future reference. Operator is adjusting rheostat to produce conditions much in excess of actual practice, to prove that the tube will give good service.

K-F Adapts Gyro-horizon For Roadability Tests

WILLOW RUN, Mich. — A Sperry gyro-horizon instrument has been adapted from aircraft to automotive test use by Kaiser-Frazer Corp. engineers to measure comparative "roll" or sway in automobiles as they round sharp road curves. Mounted on the instrument panels of test cars, the Sperry artificial horizon indicates half-degree variations from vertical stability as the vehicles negotiate identical curves at various road speeds.

In a series of comparative tests, the instrument showed that the Kaiser and Frazer automobiles were subject to from 50 to 300 percent less sway* than an average of all makes tested. In addition to the aircraft gyro-horizon, Kaiser-Frazer experimental engineers have borrowed other aviation developments.

*We admit we're confused by what the automobile publicity man wrote: "50% less sway" means half. "100% less" would mean no sway at all; does "300% less sway" mean 200% negative sway—centripetal instead of centrifugal? We just don't know! . . . Anyway, the CARS are better than the publicity.—ED.

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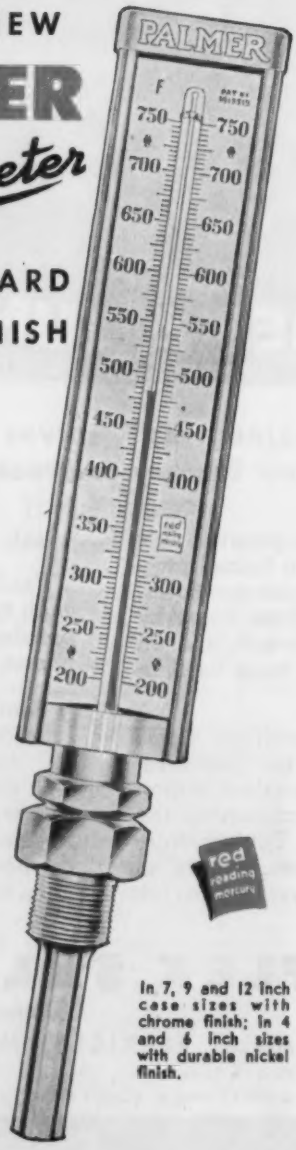

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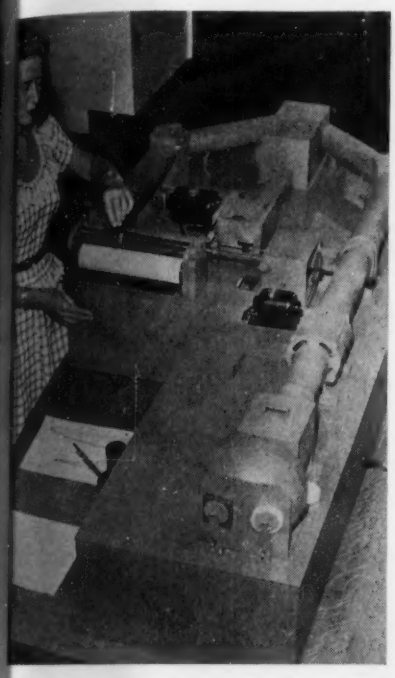
Study Food Colors

ALBANY, Calif.—Shown in operation is the General Electric recording photoelectric spectrophotometer which is being used in the U. S. Department of Agriculture's Western Regional Research Laboratory here to grade the color of processed foods and to study



color changes in foods due to processing or storage conditions. This laboratory is one of four which conduct research in methods of turning surplus or waste agricultural products, and their by-products, into useful, profitable commodities. It also develops new and improved agricultural products.

UAL Steps Up Instrument Training of Pilots

CHICAGO.—An extensive pilot training program looking toward the use of automatic airport approaches has been undertaken by United Air Lines, it was announced by J. A. Herlihy, vice president—operations.

For the past few months United has been installing Sperry A-12 Gyropilots —incorporating automatic approach controls—in all its four-engined Mainliner 230 planes. Similar equipment, manufactured by Eclipse-Pioneer Division of Bendix Aviation Corp., has been ordered for the company's Douglas DC-4's, Martin 303's and Boeing Stratocruisers which are to be delivered in 1947 and 1948. After thorough testing of the instruments and training of flight personnel in their use, automatic airport approaches will be adopted as a standard procedure on United's coast-to-coast and Pacific Coast system.

United is installing automatic radio navigational controls in its 14 Link trainers for ground instruction. Also, the company has equipped two Douglas C-47's with full instrument landing equipment including the Sperry A-12 Gyropilot for flight training. The Link trainers are being equipped with new-type Curtiss-Wright instruments, including automatic direction finder, which give them virtually the same automatic airport approach controls as those being installed on United's four-engined planes. By use of the new training equipment, any desired problem can be set up on the automatic radio range to simulate instrument approach. Fan markers can be set at any distance from the range station so that their signals will be received by the pilot when his simulated "flight path" passes through the marker position. Even wind—up to 120 miles an hour and from any direction—can be introduced into the problem to make it wholly realistic.

United's pilot training program for automatic airport approach calls for ability to pass an oral or written examination; extensive time in a Link trainer equipped with the new automatic controls; hours of training in planes equipped with the new instrument landing devices but with let-downs being made entirely by manual control; a specified number of low approaches to a 50-foot altitude over the airport using the full automatic equipment, and hours of practice in low approaches while "under the hood."

Gaertner

CATHETOMETERS

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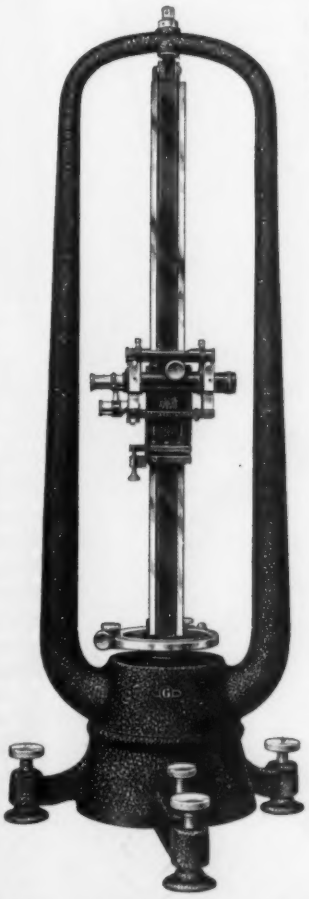
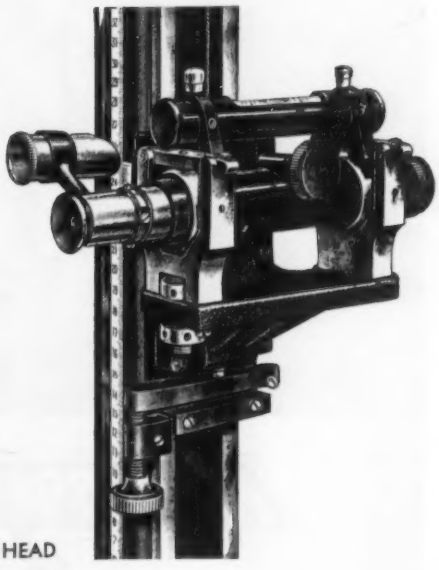


When measuring an object inaccessible by ordinary means, a cathetometer is indispensable. The instrument illustrated is one of more than a dozen models described in catalog M138.

M903 CATHETOMETER. Supplied with ranges of 65 cm. or 100 cm. A similar instrument, but with two telescopes, is available.



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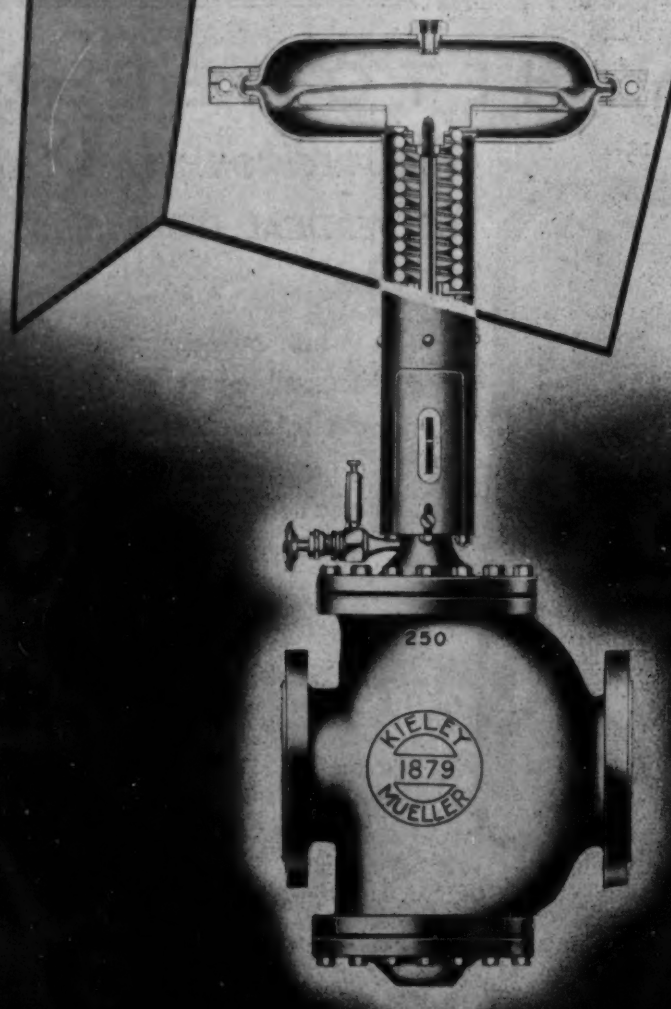

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Vol. 2 APRIL 1947 No. 4

Editorial

ELP, HELP!"

We believe that an editorial column offer no finer service than to supply o where help is needed, or, looking it from another angle, to ask for o where help is requested through n channels. We have received a num- of requests for this latter type of vice, and it has always been, and continue to be our great pleasure oblige to the fullest extent of our ility.

ur latest request is for action. The ployment Committee, which will its first general meeting in Cleve- on April 23, has on its agenda for meeting discussions covering the loyment registration form, student istration, employer registration, co- inating efforts of the Central Regis- ion Bureau and the local Section ployment Committee, and *the Em- ment Register at the Second An- Conference and Exhibit in Chi- this coming September.* It is this item which requires some action on part of the various Sections, and sooner the better.

o bring us up to date on the matter, would like to point out that on uary 15th, Chairman Goldcamp of Employment Committee sent out a er to all Sections explaining the posed Register, and asking that Section submit the names of indi- uals responsible for employment of rument men in the industries and panies encompassed by the mem- ship of that Section. To these indi- uals a letter was to be sent explain- the activities of the Employment mittee and urging them to take ad- tage of the Register which will be peration at the Chicago Conference September.

uoting from this proposed letter, e I.S.A. Employment Register at Second Annual Conference will pro- an 'on the spot' mechanism for ging applicants and employers' esentatives together. The Register provide suitable facilities for per- l interviews scheduled at the con- ence of the prospective employer, f desired, the applicants could be to the hotel address of the em- ers' representative who requests Through the pages of the *Journal* of I.S.A., those seeking interviews will urged to register at least two ths prior to the week of the Con- nce so that the prospective employ- ill have the opportunity of review- the records of the applicants and cting those he would like to inter- . This procedure would necessitate stering the open position with the loyment Register prior to the Con- ference so that properly qualified records could be forwarded. Last minute interviews can be arranged during the Conference if necessary. There would be no obligation to the Society on the part of either the prospective employers or the applicants."

It is gratifying to announce that the mechanism for the operation of the Register at the Conference has already been set up, thanks to the efforts of Howard Knight, chairman of the Chicago Section Employment Committee, and arrangements have been completed for the "manning" of the office of the Register during the entire time. Now it is up to the Sections, the employers, and the applicants, and here are the requests for action:

1. To the Section—please submit the names of prospective employers to Mr. Goldcamp before May 1 so they will be on the mailing list when the letter goes out explaining the purpose and operation of the Employment Register at the Conference. Individuals, submit the names of your superiors or the person or persons responsible for employment in your company.

2. To Applicants — this is the first official call to register with the Central Registration Bureau. If you desire interviews at the Conference, try to be registered not later than the first week in July. Last minute registrations will be handled by the Register at the Conference, but it is much more advantageous to have your record in the hands of prospective employers before they leave their office for the Conference, and this can only be accomplished by early registration.

3. To Employers—register your "positions open" with Mr. Goldcamp, and then plan on using the services of the Register at the Conference to secure top-notch men to fill your needs.

4. To the Employment Committee—you are welcome, and in turn thanks for the fine job you are doing.

Further announcements will be published from time to time in the *Journal* and it is planned to publish a full up-to-date report of the activities of this committee in the June issue. Our sincere hope now is that the action requested herein will be shortly forthcoming, thereby greatly increasing the value of the society to all concerned.

—RRP

THE SCOPE OF ENGINEERING EDUCATION IN INSTRUMENTS

(A guest editorial by Professor Carl F. Kayan, First Vice-President)

The need for course work in instruments, as well as an appreciation of its educational complexity, has been receiving a growing recognition on the part of engineering schools throughout the country. In general it is accepted that a balanced course or series of courses in our field must be based on a sound understanding of the fundamental engineering subjects. These include not only the basic sciences of physics, chemistry and mathematics on the one hand, but also, on the other, such technical subjects as thermodynamics, heat transfer, fluid flow, analytical mechanics, and electromechanics, to name the more important ones.

On these obviously rest the development of work not only in instruments for indicating and recording, but also in their application to automatic control, including the general problem of control theory as involving dynamic and transient systems.

One phase of instrument study that has not been as thoroughly recognized is that concerned with computing devices, especially of the automatic type. These as a group rightfully constitute a broad field of activity, highly developed during the war, and which should have some treatment in our engineering curricula. It is immediately granted that such applications represent a highly specialized subject. An engineering student in instruments, however, should at least have an introduction to some of the principles. Included herein should also be the solution of problems by analogies, such as electrical and hydraulic, since this procedure represents prediction of results through substitution of an available process of instrument application for another usually more difficult and often impossible.

Such studies should thus more fully round out the engineering study of instruments.

Editor's Notes

1. FIRE-BUILDERS, INC.

Without fully realizing it, we struck responsive chords in several Sections with our editorial "Cooperation" which appeared in the February issue of the *Journal.* We have received several congratulatory letters and promises of action, and were pleasantly surprised when we received the Detroit Section's publication, *The Recorder* (March issue), to find that a follow-up editorial based on our "fire-building" article was the feature of the magazine. Incidentally, our Editor-friend Sig Kulka did himself proud on that editorial, and we intend to quote from it the next time we feel the need of starting some more fires.

One of the most interesting letters just arrived from J. L. Lopez, Secretary of one of our newest Sections—Aruba—and we quote herewith some of the more pertinent remarks from his letter:

". . . you and I are in full accord regarding the I.S.A. and 'Cooperation.' Your editorial should be repeated frequently in perhaps more condensed form. Cooperation is what we have been trying to put over to our members. Some individuals seem to have the attitude 'why should I do this or that?' We have instances where committees are not carrying out certain phases of their as-

(Continued on page 377)

Surface Finish Measurement Instrumentation*

By JAMES A. BROADSTON, North American Aviation, Inc., Los Angeles

GREAT opportunities now exist for the future improvement of surface finish measurement instrumentation, since none of the existing instruments for the purpose are completely satisfactory.

Even greater opportunities exist for those who increase the utilization of existing instrumentation in controlling the surface quality of products whose performance depends upon proper surface finish.

Surface quality control today lags far behind existing instrumentation primarily because there are so many men now in industry who do not realize that this instrumentation is no longer a laboratory curiosity but has grown up to the point where it can offer real and tangible help in all machine shops, instrument laboratories or wherever any machine work is done.

Many of you may say to yourselves that you only make a few special precision parts; that you do not have any real production to speak of; or that all of your men are specialists and that you never have any trouble with surface finish anyway, so why bother. It is my purpose to help you to realize that you are wrong—to help you realize that there is a place in your shop for a program of surface quality control whether it has but one lathe or consists of a whole factory full of machinery. Such a program will include not only the use of proper instrumentation but also the adoption of a practical system of machine finish designation for drawings of machined parts.

The particular instrumentation needed will depend largely upon the type of work done. An attempt will be made to give you some ideas that will assist in making the proper selection.

My convictions offer a challenge both to the users of such instrumentation and to the designers of such instrumentation. They constitute a double challenge to those who are willing to take an interest in the future.

As C. F. Kettering has so aptly said: *"My interest is in the future because I am going to spend the rest of my life there."*

Unless we make an effort today to improve the conditions of the past the future will not be any better. It is what we do today, tomorrow and the next day that counts.

Industry Has Progress Habit

Let's go back into the past a few years and build a perspective view of the manufacturing industry's habit of progress so that we can see how surface finish instrumentation and its proper utilization fit into the scheme of things.

There are many men now in industry who can easily remember when there were only two kinds of steel—"ordinary steel" and "tool steel." The only distinction between them was that one used tool steel to make the tools for cutting the ordinary steel. When the quality of the ordinary steel was improved so that it could be cut more readily it was called machine steel. Salesmen sold their tool steel by putting on a shop demonstration to show that their tools would do a better cutting job than the steel their competitors offered. It was all just as simple as that. Quality was judged by performance.

Since that time superior steels have been created that are specially suited to literally hundreds of applications. Great progress has been made.

There are many men now in industry who can remember the days when every first class machinist was his own inspector and assembler. Those were the days of the small shop—before mass production and interchangeable manufacture. A machinist could do the whole job from the roughly penciled sketch to the finished machine. At that time he had probably never heard of "tolerances" but he knew how to make shrink fits, drive fits, sliding fits and running fits. He knew which parts had to fit together and which were the mating surfaces of each. He took special care to make his journals and shafts smooth. He was an accomplished craftsman who had spent many years both as an apprentice and as a journeyman machinist in learning his trade. He naturally took pride in his work. He knew his success or failure on the job was dependent upon how well his machine worked. Their quality was judged by their performance and appearance.

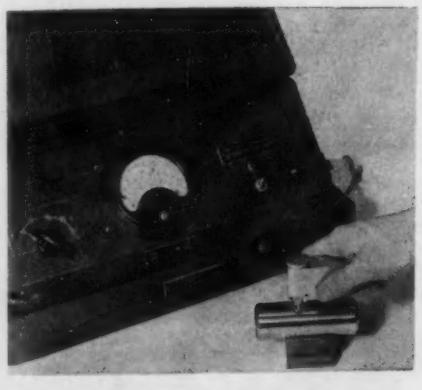


Fig. 1. Profilometer. (Courtesy Physicists Research Co.)

In some industries, where mass production and interchangeable manufacture have made it necessary, dimensional limits have had to be imposed that mating parts could be assembled easily and accurately and so that spare parts that would fit could be supplied to distant customers. Now there are literally thousands of different types of instruments and gages for controlling the dimensional tolerances of these parts as well as the composition and physical properties of the materials from which they are fabricated. Great progress has been made.

Measurement Instrumentation Is Practical

Before equal progress can be made in controlling the surface quality of machined parts it will be necessary that thousands of men of responsibility

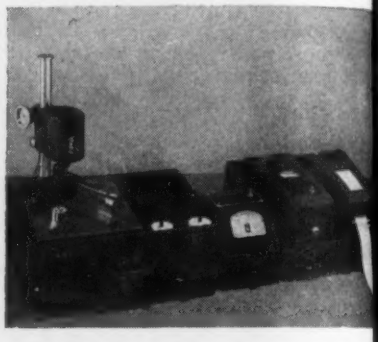


Fig. 2. Surface analyzer. (Courtesy Brush Development Co.)

industry come to the realization that surface measurement instrumentation *can* be brought out of the laboratory. It can take its place on the production line or in the small shop and can be used to great advantage in improving product quality and reducing costs. In some of the more progressive plants this has already been accomplished.

One of the principal reasons that some still consider surface finish measurement in the class of laboratory technical hocus-pocus is that most of the articles on the subject have been written by research men who were seeking better ways to measure surface finish. These articles have dealt primarily with the technical details of their investigations. Most of these hold little interest to the practical man. Usually these research men or technicians have described instrumentation which at the outset appeared beyond the reach or need of the practical man's shop. These practical men would ask themselves "Will it pay its way?" To most of them the answer was always "No!"

In many cases the answer was correct—not because the instrumentation was at fault—but largely because the

*Presented at the first Annual Conference of the Instrument Society of America, William Penn Hotel, Pittsburgh, Penna., Sept. 16-20, 1946.

NOTE: Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

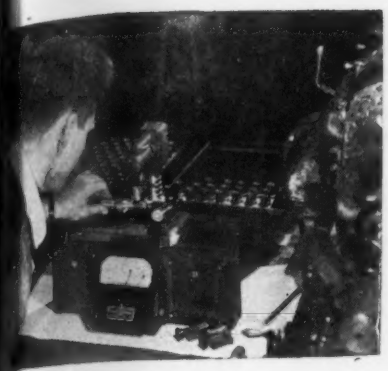


Fig. 3. Surface comparator. (Courtesy The Comtor Co.)

was no one in the organization with the necessary experience to use the instrumentation to full advantage and thereby make it a paying proposition. There are several large nationally-known manufacturers who have invested thousands of dollars in instrumentation which is now stored away in their laboratories collecting dust because no one has the vision to bring it out and use it to advantage. Education in this new science of surface quality control is most important.

In the short span of time I have been on this earth I have come to the conclusion that the only reason grown men of intelligence disagree on technical matters or manufacturing processes is that they do not all see the problems clearly or understand them as thoroughly as they should. As soon as they each know all of the facts and get the proper perspective on them their agreement is usually unanimous.

King Solomon, in exhorting his son to wisdom said: *"Wisdom is the principal thing; therefore get wisdom; and with all thy getting get understanding."*

It is hoped that this presentation of some of the facts about surface quality control through the use of proper instrumentation will be helpful and bring a touch of wisdom to many who have not had time to learn of its great possibilities. Perhaps from this they will learn that a program of surface quality control can prove valuable and gain a determination to do something about it.

Surface Quality Is Important

First we must find out why surface quality is important. A few months ago I had the pleasure of receiving a letter from R. E. W. Harrison, now Vice President of the Chambersburg Engineering Company. I was associated with him almost twenty years ago while he was Chief Engineer of Cincinnati Grinders, Inc. Mr. Harrison was a real pioneer and was the first person to set up a series of samples of ground finishes for direct comparison with parts in process. They were used as standard check pieces by both our own shops and those of the Cincinnati Milling Machine Company.

We had been discussing surface quality control and its importance to industry. In his letter Mr. Harrison said:

"A whole textbook could be written on the history of the endeavor to set up surface quality standards, but despite all the setbacks and oppositions the fact remains that surface quality control is even more important than rust prevention inasmuch as improper control of quality wears out more machinery than any other single factor.

"Probably the one fact which accounts for the ability of the modern motor car to run one-hundred thousand miles with the same engine is the circumstance that better finishes under proper control are now applied to all wearing or loaded surfaces."

It is obvious that were it not for surface finish measurement instrumentation such "proper control" would be impossible. As a result the automobile industry has been one of the leaders in making such instrumentation pay its way—particularly where very finely finished surfaces are used.

The products of the automotive industry could be improved even more by a further use of surface quality control and designation. At the same time they could reduce their costs by many hundreds of thousands of dollars per year by merely extending control to rougher surfaces and not doing any machine work finer than necessary.

Surface Quality Influences Life

It has been said (and for many parts it is true) that the quality of the surface finish may have a far greater influence upon the life and proper functioning of a part than either its composition, strength or dimensions. Since adequate controls are set up for these latter properties is it not reasonable to believe that the proper control of the surface finish would be even more worthwhile? This statement should not be construed to mean that super-smooth surfaces should be used everywhere. This is decidedly not the case. From an economic standpoint rougher surfaces cost less than smooth ones.

It is seldom good economy to make a surface smoother than it really needs to be, unless it can be finished at the same time another adjacent surface is finished or unless the only means of sizing will actually produce a smooth surface. The adoption of a proper drawing notation which will point out those surfaces of a part which need special care and a fine finish and those which can be allowed to remain rough will reduce costs by preventing misapplication of effort.

For example, suppose we consider a very simple part such as the piston and rod assembly of a hydraulic strut.

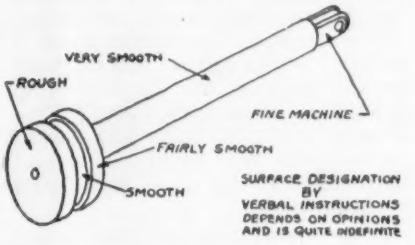


Fig. 4

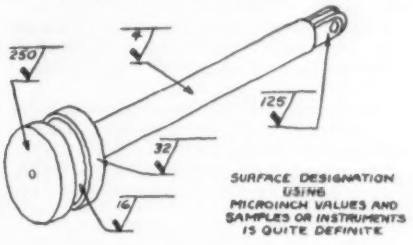


Fig. 5

If the old-time machinist were asked to make it he would undoubtedly finish it smooth all over. He would take pride in its appearance and he would not consider a rough surface or a chatter mark acceptable shop practice. He might spend an hour turning and polishing the flat piston faces and an equal time on the rod itself.

Designate Critical Surfaces

To reduce costs and improve quality through the adoption of surface quality controls it must be determined which surfaces are critical and which are not. The designer is best able to determine these facts at the time the drawing is made. In this example the rod itself must slide through a packing gland and *must* therefore be smooth. The outside edge of the piston must also be smooth since it slides along the inside of the hydraulic cylinder, but it need not be as smooth as the rod since it is always well lubricated and slides against a smooth metal cylinder bore. The rod however must slide against a soft packing and may be dry and dusty when retracted. See Fig. 4.

The only other surfaces of importance are the packing ring groove in the piston head and the mating surfaces that attach to the machine driven by the strut.

The two flat surfaces of the piston, therefore, can be as rough as normal rapid machining processes will leave them since they only contact the hydraulic fluid or stop against the strut ends at full stroke.

It would therefore be advisable to inform the machinist and inspector of these facts by designating the required surface quality for each surface of the part by calling out roughness values on the drawing, as shown in Fig. 5.

Such roughness numbers indicate the maximum allowable average surface roughness in microinches as indicated by either an instrument or by fingernail comparison with standard roughness blocks having known roughness values.

From these notations the machinist will know at once that the piston rod must be very smooth, the ring groove not quite as smooth, the piston periphery just smooth but the flat ends of the piston can be rough. He will therefore put the time into the surfaces that need special care and let the rest go. Of course they must still be held to proper dimensional tolerances. His boss

will not question his work when the drawing clearly indicates that some surfaces can be rough. Even on one simple part, time and effort can be saved, and the part is better for the use of a roughness designating system and better control.

There are many parts where it would be almost impossible for anyone but the designer to know which surfaces are critical and which are not. If the designer designates the required finish for the critical surfaces and gives a generous overall roughness allowable for the non-critical ones, substantial savings will accrue, or for equal cost more perfect critical surfaces can be prepared which will improve product quality and life.

Surface Roughness Is A Vital Quality

There are many other reasons why surface finish control is important but they can only be mentioned here.

Among the qualities that are affected by changes in surface roughness might be included:

1. Life—how long will it last? Remember friction, abrasion, wear, lubrication, bearing area, corrosion and galling.

2. Safety—how strong is it? Remember stress concentrations, fatigue strength, notch sensitivity and imposed loads.

3. Function—will it work properly? Must it slide freely, fit properly, prevent leakage, serve as a bearing, as a mating part or rub over packings without damaging them?

4. Appearance—does it look good? How about adhesion of plating or other protective coatings such as paint? Is appearance important?

5. Heat transmission—rough surfaces are good radiators and heat absorbers, smooth surfaces serve better as insulators.

6. Are optical properties important? Mirrors and lenses: transmission, reflection, refraction, of light or heat?

Instrument manufacturers and men in instrument laboratories and model shops have often asked how such a program of surface finish control through proper drawing designation and the use of instrumentation could help them to reduce costs, particularly when only a few special parts are to be made.

That can best be illustrated by an experience I had while in charge of our structural testing laboratory. We were testing a large airplane and we needed a solid and rigid base extension for a large 20-ton house-mover's type of screw jack. Wood shoring would not do so I sketched a base to be made of a large piece of pipe about 10″ in diameter and about 6″ high.

The following morning I went in search for the part and found it—almost finished—still chucked up in the lathe where the night man had spent the whole night boring, turning and polishing. It was a beautiful piece of work—exactly to size and perfect in finish in every respect. It would have been an addition to be proud of in any display—*but*, all we needed was a rough sturdy spacer! What a waste of time and effort!

If I had been able to easily designate a rough surface on the sketch that all parties concerned would have understood it would have been so much better.

It appears as though a tradition has been built up in the instrument industry that all surfaces on parts must be finished to perfection. Often that may account for what outsiders may consider an unjustifiably high cost. Users of instrumentation will usually agree that it is more important that an instrument operate properly and dependably than that it look pretty. Unless the surface finish is essential for proper functioning it is wasted. Proof of quality lies in performance. Waste can never be justified. Of course an attractive case and neat design help sell the instrument and they may be justified, but it would be advisable to be watchful against wasted effort that does no one any good.

When we speak of surface finish measurement instrumentation we refer to all devices that may be used in controlling the surface quality of parts or products whether machined or produced by any other process. While it is true that most of the emphasis has been placed on controlling the surface quality of machined parts it is often even more important that the surface quality of the product be held to conformance with certain roughness standards. (Two recent inquiries that come to my mind were in connection with controlling the roughness of a plastic wire covering that was extruded onto the wire and one for controlling the grain of lithographic plates.) Measurement instrumentation and roughness replicas for fingernail tactual comparison can be made for almost any purpose.

It may seem paradoxical that in one breath I say that great opportunities exist for the improvement of surface finish measurement instrumentation itself and in the next I urge that all should make greater use of such instrumentation.

A good thing may not necessarily be perfect. In fact, very few things made by man are perfect. I hope to make it clear that existing instrumentation, though admittedly far from perfect or ideal, is nevertheless very useful and is not being used as extensively by industry as it should.

There are two sides to the subject. One is that of the instrument designer, the theorist, the technician or whatever you may call the critical fellow who makes progress by striving for an ideal or for perfection. He studies the subject of measuring surface roughness thoroughly, analyzes existing instrumentation and says to himself, "These gadgets don't do what they should—they have limitations—they won't do this—they won't do that—so none of them are any good."

He is the fellow who writes most of the technical articles on the subject and explains to others like himself what a difficult problem surface finish measurement really is. What he usually succeeds in doing is scare away the practical man who would be bored by the subject anyway.

The other side of the subject is that of the practical man, the management, the shop superintendent, the chief engineer, the machine shop foreman, the inspection department. These are the ones to whom this paper is primarily directed. They are the ones who have been neglected by the authors. They are interested in whether surface quality control can show a profit for them. Will it pay its way? Will their product be better and will costs be cut if they use it? They don't care whether surface finish is measured in microinches or flubdubs. They don't care whether the instruments are accurate or not, as long as they all give the same roughness reading on the same surface. Of course national standardization would appeal to them for then all of their suppliers and their customers would have a mutual understanding of what is meant by each designated surface roughness. (That, by the way, is not possible even today for those who have not adopted a system of surface quality control. Refer to page 707 of Mary R. Norton's article on the development of standards for Army Ordnance finishes in the October, 1942, issue of *Mechanical Engineering* and see for yourself what a big difference in interpretation the various arsenals had before the war started. Everyone's opinion as to the meaning of surface finish symbols differed. The Ordnance Department had to do something about surface roughness designation and surface quality control. They had a war to win!)

When their drawings are sent out for bids, the subcontractor would know what finishes were wanted. Plants from coast to coast could produce identical parts from the same drawing and the surface finishes would be correct. Engineering, inspection and shop would not need to spend hours arguing about whether the finish of a part in process was satisfactory or not. The manufacturing department could use any process they wished as long as they obtained the required finish.

Yes, the practical man has some good points there. He can see merit in adopting a system of surface finish control in just his own plant, even to the exclusion of all others, when he knows the facts. He will agree that perfection of the instrumentation is a good idea, but he doesn't intend to wait for perfection. He wants to use it now. Later on, when standards for surface finish become international, he can gradually change over to them, but in the meantime, while the technicians are finding better ways to measure and evaluate surface finish, he will be saving money and at the same time producing a better product.

To be concluded

Editor's Notes *(Continued from 373)*

signments because they feel that these duties come under some other committee, regardless of the fact that the Society may be left in an embarrassing situation on their negligence, or that Society activities may indeed come to a standstill.

"I feel that I am a qualified member of the 'Fire-Builders' since I was one of those instrumental in organizing our Section. Of course, there are several of us who are eligible to receive this title, and the members of our organization have recognized the fact by making us officers . . . All in all, your editorial was a huge success as far as we are concerned . . . and the guest editorial by J. B. McMahon was also very encouraging . . . We are looking forward to a great future for (and with) the I.S.A."

So, while we may not have hit the jackpot as yet, it appears that we have struck *some* pay dirt, and we hope the trend continues. These letters are very gratifying, and we'd like to receive more of them, not only for the personal satisfaction of having stirred up some activity, but because they prove that others are taking a more active interest in promoting the cooperation necessary to the successful future of the Society.

2. CLEVELAND MEETING DATES CHANGED

In the February issue of the *Journal* it was reported that the Regional Meeting to be held in Cleveland, Ohio, was to be held April 4-5. Shortly after this notice was published, the Cleveland Committee and the National Office found it advisable to change the dates to April 23, 24 and 25. While the correct dates were announced in the March issue, and by letter to the various Section officers, we believe it worth while to again call it to the attention of all concerned. A schedule of activities of this meeting will be found in these columns, and we urge everyone who can possibly attend to join us in Cleveland and participate in these activities.

3. STATUS OF 1947 CONFERENCE

It is our intention to keep our readers as well posted as possible on the progress being made in arrangements for the 1947 Conference to be held in Chicago next September 8-12, and we will release committee reports, progress reports, general news items, etc., as rapidly as they become available to us. The main item of interest to report this time is that over two-thirds of the exhibit space in the Stevens Hotel Exhibition Hall has already been sold at this writing. The 100th booth was assigned at a meeting of the allocation Committee early in March, and a good many more will have been assigned before this issue of the *Journal* is off the press.

All committees necessary to handle the details of both the Conference and the Exhibit have been set up, and confirmation of personnel has been obtained in most cases. It is hoped that we can publish the complete list of committees and their personnel in either the May or June issue. Many of the committees have, of course, been active for many weeks.

It is also hoped that the Exhibition Hall layout with a complete list of exhibitors can be published within the next month or two.

It is not too early to start making your plans NOW to attend this Conference and Exhibit — Stevens Hotel, Chicago, September 8-12, 1947.

4. FOUR MORE NEW SECTIONS

Since our last report on new Sections (March issue) four more charters nave been granted, bringing the total number of Sections as of this writing to 30. The four new Sections are:

Cincinnati (Ohio), Louisville (Kentucky), South Bend (Indiana) and Twin Cities (Minneapolis and St. Paul, Minnesota).

We extend a hearty welcome to these new Sections. We feel sure that their affiliation with the Instrument Society of America will prove to be of mutual benefit to all concerned.

5. SUGGESTIONS WANTED

In a recent letter from the Secretary of the Aruba Section (from which we quoted elsewhere in these columns) one paragraph stood out like a sore thumb, being, as it was, a thinly veiled plea for help. We have decided that the Journal is a good medium through which the request can be brought to the attention of someone who can be of assistance, so again we quote Mr. Lopez:

". . . If the National Office (or anyone else) could help us out on arrangements for speakers we would surely like to know about it, since we are in somewhat of a dilemma on this subject. Speakers in Aruba are as scarce as the proverbial 'hen's teeth.'"

We grant that their problem is a special one. Perhaps someone has some suggestions to offer; if so, just drop a note to J. L. Lopez, c/o Lago Oil & Transport Co., Ltd., Aruba, Netherlands West Indies, and we know they will be appreciated.

6. THE NEEDLE POINTS TO—

Aruba, Detroit and Pittsburgh, for general excellence with the least editing required.

Oak Ridge, for completeness and timeliness.

New Jersey, for some expressions of opinion which might prove of general interest. (Fire-Builders in action?)

—R. R. PROCTOR.

Official News

SCHEDULE FOR SPRING MEETING IN CLEVELAND APRIL 23, 24, 25

The Spring Regional Meeting to be held in the Carter Hotel in Cleveland on April 23, 24 and 25, has been scheduled as follows:

April 23 (Wednesday) Committee Meetings. Two committees which have already made arrangements for meetings on this date are the Educational Committee (Dr. B. R. Teare, chairman), Recommended Practices Committee (F. Trapnell, chairman), Finance Committee (A. Shafer, chairman) and the Employment Committee (C. F. Goldcamp, chairman).

April 24 (Thursday), Technical Sessions. See details of program below.

April 25 (Friday), meetings of the Executive Committee and the Board of Directors. The agenda for the meeting of the Board of Directors is as follows:

1. Roll call and greeting of new members of the Board of Directors, including any from the following new Sections and applying groups: Aruba, Central Indiana, Cincinnati, Eastern New York, Louisville, South Bend, Twin Cities, others.
2. Minutes of the previous meeting.
3. Reports of the National Committees:
   - Committee on Committees, W. A. Wildhack, Chairman.
   - Constitution Committee, H. F. Moore, Chairman.
   - Educational Committee, B. R. Teare, Jr., Chairman.
   - Employment Committee, C. F. Goldcamp, Chairman.
   - Finance Committee, A. H. Shafer, Chairman.
   - Meetings Committee, A. F. Sperry, Chairman.
   - Membership Committee, R. Rimbach, Chairman.
   - New Sections Committee, J. B. McMahon, Chairman.
   - Nominating Committee, E. C. Rieger, Chairman.
   - Publications Committee, R. H. Munch, Chairman.
   - Public Relations Committee, C. O. Fairchild, Chairman.
   - Recommended Practices Committee, F. H. Trapnell, Chairman.
   - Research Committee, R. H. Muller, Chairman.
   - Special Committee on Delegates' Expenses, A. Sperry, Chairman.

   (Many of these reports will require action by the Board of Directors, and careful attention of the members is urged by the Executive Committee so that considered action may follow.)
4. Action on committee reports.
5. Further new business:
   - (a) Discussion and progress reports of 1947 Conference and Exhibit.
   - (b) National vs. Section responsibilities regarding meetings.
   - (c) Section constitutions and by-laws.
   - (d) Naming of Sections.
   - (e) Clarification of authority of officers.
   - (f) Secretary's special reports.
   - (g) Discussion of prospective speakers' co-ordination bureau.
   - (h) Final action on Society emblem.
   - (i) 1949 Conference and Exhibit.
   - (j) Other business as may come up.

In addition, there are a few items of old business which will be brought up for further discussion or final action.

General News

PROGRAM FOR THE CLEVELAND MEETING

The program for the sessions of the Spring Meeting of the I.S.A., to be held at the Carter Hotel, Cleveland, Ohio, Thursday, April 24th, is as follows:

REGISTRATION—9 A. M.
See Hotel Carter Bulletin Board for location of registration and meeting rooms.

MORNING SESSION—9:30 A. M.
Chairman: S. Bousky, President of the I.S.A. Cleveland Section.
Welcome: C. O. Fairchild, President of the Instrument Society of America.
Measurement of Light
Harvey Rockwell, Consulting Engineer.
Progress in Quality Measurement For Process Control
Nelson Gildersleeve, General Electric Co.

LUNCHEON—12:30 P. M.
Modern Electronic Developments For Automatic Control
Gordon Volkenant, Minneapolis-Honeywell Regulator Co.

AFTERNOON SESSION—2:30 P. M.
Chairman: A. A. Hejduk, Chairman Spring Meeting Program Committee.
Gadgets, Gimmicks and Ways Out
W. H. Fortney, Humble Oil Co.
Instrumentation in Atomic Energy Research
John Victoreen, Victoreen Instrument Co.

DINNER—7:30 P. M.
Measurement—Tool of Science and Industry
Dr. Hugh L. Dryden, Associate Director, National Bureau of Standards
Entertainment

TO ALL SECTION SECRETARIES

We take this means of informing Section Secretaries of some changes and additions to be made in their records and in the list

of Delegates, Secretaries and *Journal* Correspondents as published in the February issue of the *Journal*.

Please make the following changes:

Cumberland Section: New Secretary—Clyde Babst, P. O. Box 447, Cumberland, Md.

Gulf Coast Section: Delegate—R. L. Nichols, 715 Madison St., Beaumont, Texas (formerly Sec'y-Treas.) New Secretary-Treasurer—A. E. Bunn, 2237 North St., Beaumont, Texas.

Please add the following to the previously published list:

Aruba Section: Secretary—J. L. Lopez, c/o Lago Oil & Transport Co., Ltd., Aruba, Netherlands West Indies; Correspondent—same; Delegate—none elected.

Central Indiana Section: Secretary—Morris R. Underwood, 1235 West 33rd St., Indianapolis, Ind.; Correspondent—M. W. Hanson, c/o P. R. Mallory Co., 3054 E. Washington St., Indianapolis, Ind.; Delegate—none elected.

Eastern New York Section: Secretary—W. J. Claffie, 407 State St., Albany, N. Y.; Correspondent — same; Delegate — none elected.

Conference Papers Quoted In Scientific Journal

Of interest to I.S.A. members is the fact that there was published in the March issue of *Scientific American* an article entitled "Instrumentation — Measurement and Control," which covers the papers which were presented at the First National Instrument Conference in Pittsburgh last September.

The article covers three pages and was written by Dr. Alexander Klemin, a member of the New York Section.

Section News Department

ARUBA

Our eighth meeting was held on March 4, 1947, at the Engineers' Club Building. Eighteen of the twenty-two charter members were present when President A. S. MacNutt brought the meeting to order and welcomed four new members to their first meeting.

Following the report of Treasurer W. A. Koopman, M. A. Davidson was appointed our representative on the Community Council to correlate our community efforts with those of the other organizations of the Colony here.

After the regular business was out of the way, Fred Eaton of the Technical Service Division of the Aruba Refinery presented an interesting talk on "The Cathode Ray Oscilloscope." He talked for well over an hour, during which time he covered "why" and "how" it works. He demonstrated how it could be used in trouble-shooting on an amplifier unit of an electronic temperature recorder. With a microphone he demonstrated how sound "looks." He even showed us how a "wolf call" looks on the 'scope.

After Fred's talk the meeting was adjourned, and coffee and sandwiches were served while the members gathered around the demonstration table for more informal discussion and a closer look at the equipment used.

Our next meeting will be at the same time and place on April 1, 1947. Our Project Committee has not worked out the details of the program for the evening as yet. However, during the month of April we plan to have two motion picture films, either for our regular meeting or at special showings to be announced at a later date. The films are "The Theory of the Automatic Pilot" and "The Power House of Aviation," the first film through the courtesy of the Brown Instrument Company and the latter through the kindness of the Wright Aeronautical Corporation.

—J. L. Lopez, *Sec'y.*

BALTIMORE

(Received too late for the March issue)

On Friday, February 7th, sixty-four members and guests of the Baltimore Section met at the Engineers Club of Baltimore to enjoy a very pleasant and educational evening.

A social get-together during which games were enjoyed, cocktails were served at 6:00 p. m. and a buffet supper 6:30 to 8:00 p. m. preceded the main meeting which opened at 8:15. Following the regular business meeting, Howard Halstead introduced one of the country's leading fuel engineers, Andrew J. Fisher of the Bethlehem Steel Company, Sparrows Point, Md., who was guest speaker of the evening.

Mr. Fisher presented a very instructive and interesting talk on "Items of Controllability in the Open Hearth Combustion Process." He discussed methods and problems relating to the recording and controlling of the various combustion factors in the open hearth process. Specific items which were covered were oil flow, steam flow, furnace pressure, checker temperature, reverse cycle, flame radiation and combustion air temperature. His talk was well illustrated by slides.

The program was sponsored by the Brown Instrument Division and the Minneapolis-Honeywell Regulator Company. At the close of the meeting refreshments were served.

On February 11 the Council of Officers of the Baltimore Section met for the purpose of drawing up a set of By-laws. On Saturday, February 15, twenty members of the Section made a tour through the manufacturing plant and laboratories of the Maryland Glass Company. The trip was conducted by Thomas Coyle and Donald Donahue of that organization, who explained the many processes in the production of glass, with emphasis on the automatic feeders and the automatic thermal control instruments.

—Kenneth R. Miller, *Corr.*

CENTRAL INDIANA

(Received too late for the March issue.)

Having received its charter from the Instrument Society of America, the Indianapolis Technical Instrument Society conducted its first meeting as the Central Indiana Section of the I.S.A. on February 4, 1947. The meeting was held at the Indiana War Memorial and, in spite of stormy weather, was very well attended.

An interesting and instructive talk, illustrated by slides, on "Electric Meters and Their Application" was given by J. Montgomery, Electrical Engineer and Equipment Designer for the P. R. Mallory Company. Mr. Montgomery is also a member of this Section. His talk covered a brief survey of all types of electric meters and the application for which each is best suited. Construction and accuracy of each type was stressed.

Following Mr. Montgomery's talk, President H. P. Rockwell introduced J. B. McMahon, a Vice-president of the Instrument Society of America. Mr. McMahon welcomed the Section into the organization, and outlined future plans of the National Society and the advantages this Section and its members would enjoy in its affiliation with the I.S.A.

The next meeting of this Section will be held on March 4th. Charles A. Packard, Consulting Relay Engineer, is scheduled to give a talk on "Relays and Instrumentation."

—M. W. Hanson, *Corr.*

CHARLESTON

Monday, April 7, "Rotameters — Recent Improvements and Applications," Fischer & Porter Company.

Monday, May 5, "Combustion and Feedwater Control," C. H. Barnard, Bailey Meter Company.

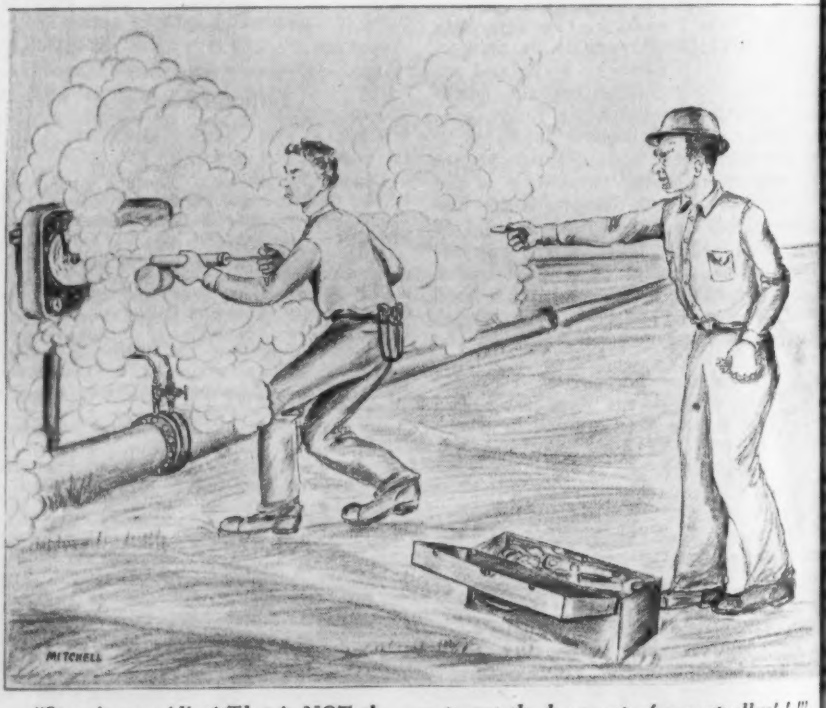
—Carl Cavender, *Sec'y.*

CHICAGO

The March 3rd meeting of the Chicago Section was held at the Builders Club where over a hundred members and guests gathered to hear A. S. Kyle, of Claud S. Gordon Company, speak on "Instrument Maintenance." Mr. Kyle's talk dealt primarily with electrical indicating instruments, and was illustrated by very well drawn blackboard diagrams.

On Monday, April 7, the Chicago Section will enjoy an inspection trip through Northwestern Technological Institute, following dinner at the Georgian Hotel in Evanston.

The date of the Social Night has been changed from May 5 to May 12. This meeting, for members and guests and their wives or sweethearts, will be held in the Furniture Club, 666 Lake Shore Drive. Dinner will be served at 6:45 p. m., followed by the Annual Business Meeting and installation of new officers. Entertainment of var



"Stop it, you idiot! That is NOT the way to get the bugs out of a controller!!"

types will complete the meeting, the ture of the evening being an hour of sic and mind-reading by a well-known fessional magician.

—JOHN C. VAALER, *Corr.*

CLEVELAND

At the regular March meeting of the veland Section of I.S.A. held March 26th Warner Auditorium, an interested audi- e heard Charles Saunders, Vice President Wheelco Instruments Company, tell of his perience on a recent European trip. ong other things, he pointed out that rumentation in Europe was comparable our development about fifteen or twenty rs ago.

A formal constitution and set of by-laws accepted by the membership. The follow- officers were elected for the 1947-48 on to be inducted at the May meeting: sident, Samuel Bousky; vice president, thur A. Hejduk; secretary, Clarke Joy; asurer, Joseph A. Prada.

For our April program we will be the ts of the Spring Regional Meeting to be d at the Hotel Carter April 24th.

—R. M. WOODSIDE, *Corr.*

CUMBERLAND

The Cumberland Section held its February ner and technical meeting on Wednes- y, the 26th, at the Queen City Hotel.

The speaker of the evening, W. O. Stoelz- of Pittsburgh, Pa., gave a very inter- ing talk on "Diaphragm Control Valves."

The next meeting will be held March 25th.

—H. E. BISHOP, *Corr.*

DETROIT

The February meeting of the Detroit Sec- was originally scheduled to present C. Tate of the A. H. Emery Company O. Heise of the Heise Bourdon Tube oratories. A snow-bound train and a ating accident combined to prevent both akers from attending. In their stead F. Tatnall of the Baldwin Locomotive rks shouldered the double duty of pre- ting Mr. Heise's paper on "Precision rdon Tube Gages" and Mr. Tate's sub- t, "The Tate-Emery Cell for Precision e Measurements."

The first paper covered the history, short- ings and advantages of the Bourdon e. It stressed the mechanical and metal- rical difficulties in producing truly de- dable, accurate Bourdon tubes, and out- d the care and precision used in making Heise precision tubes and gages.

Mr. Tatnall then figuratively rolled up sleeves and got to work on his appar- ly favorite subject, the Tate-Emery cell. covered the field in an informal manner, ssing the basic principles of the hy- ulic and pneumatic cells, the wide range forces covered (1/500 of a pound to one lion pounds), and the uses to which they been adapted. Of particular interest was application to simultaneous measure- nts of six forces in supersonic wind tun- work.

The meeting ended in a free-for-all ques- session that brought out the fact that Tate-Emery cell of 160,000 to 1 range (!) in use at one of the automotive plants e.

The S. Sterling Company, of Detroit, monstrated the new DuMont Type 427-A jection oscilloscope to all those inter- ted, which, of course, included all of the ty members and guests in attendance.

At the next meeting, to be held on Mon- March 24, the Detroit Section will pre- t F. R. Brydges, Instrument Engineer the Post Products Division of General ds Corporation, who will speak on "Un- al Control Problems," and P. C. Skeels, General Motors Proving Grounds, whose ject is "Electronics Applied to Counting blems."

On April 28 a talk on "Electronic Servo- hanisms and Automatic Controls" will presented by W. C. Robinette, of the C. Robinette Company.

—SIEGMUND KULKA, *Corr.*

EASTERN NEW YORK

The Eastern New York Section held its March meeting on Tuesday evening, the 4th, at Siena College, Loudonville, N. Y.

The program for the evening was a "Maintenance Clinic" with two speakers, John Maitland of the Bristol Instrument Company, who spoke on the "Running Time Recorder," and Harold Alford of Energy Control Company, who chose as his topic "Industrial Glass Stem Thermometers."

A question period followed each talk and at the conclusion of the meeting the equipment supplied by the speakers was examined with much interest. The meeting adjourned at 10:30 p. m.

The April 8th meeting will also be held at Siena College. J. B. McMahon of Republic Flow Meters Company, Chicago, will be the guest speaker. His talk will be "A Non-mathematical Discussion of Flow Measurement."

—W. J. CLAFFIE, JR., *Sec'y.*

NEW JERSEY

While most of our regular group were on hand at the March 4th meeting to hear Arthur Liebscher talk on "The Cathode-Ray Oscilloscope," the number of electrical people in attendance, however, was somewhat disappointing as this program was planned to be of particular interest to them. Mr. Liebscher, having wide experience in television and electrical measurement fields, gave a fine explanation of the cathode-ray tube and the use of the oscilloscope under varying conditions.

Despite the apparent lack of interest on the part of the electrical group, Sid Baran, our Program Chairman, advises that a special meeting is being planned for April and will be held in addition to our regular meeting on April 1. Men engaged in electrical instrument work are asked to support this movement to arrange programs of particular interest to them.

The speaker at the May 6th meeting will be Bruce Irwin of Hammel-Dahl Company, who will talk on "Selection of Control Valves for General Application."

The June 3rd meeting, as previously announced, will be an inspection trip through parts of the Calco Chemical Bound Brook Plant. A very interesting program is being arranged.

Bill Archibald of Energy Control Company has been appointed chairman of the local Employment Committee. Anyone in the New Jersey Section with employment problems should get in touch with Bill, who will have available the information on all jobs listed in the National Office in Pittsburgh.

—GEORGE R. FEELEY, *Corr.*

NEW YORK

The New York Section held its 47th meeting on Monday, February 24, 1947, at the Men's Faculty Club, Columbia University. Twenty-six persons were present for supper at 6:30 p. m.

The business portion of the meeting was opened by President Hildenbrand at 7:50 pm. The first order of business, the adoption of the By-laws, was accomplished by a unanimous vote. Ralph Batcher, program chairman, announced that J. C. Mouzon of the Brown Instrument Company would be the speaker for March.

President Hildenbrand then introduced the speaker of the evening, H. Ziebolz, Vice-president of Askania Regulator Company, Chicago. Mr. Ziebolz presented a talk entitled "Translator Chains, Analysis and Design." It dealt with a method of solving control problems using a system of so-called translators to indicate various functions. By arranging them in appropriate manner the solutions for problems may be obtained for electrical, pneumatic, hydraulic and mechanical conditions and results.

The functions of the many parts are reduced to a simple symbol and such extraneous details as filament heaters, etc., are ignored. A block diagram is built up of these symbols of functions, tied together by lines to indicate lines or flow or progress. Types of inputs and outputs such as mechanical or otherwise are indicated. Because functions are indicated, various means to accomplish these functions may be tabulated, inserted in the diagram, and the simplest one chosen which will accomplish the desired effect.

A lively discussion and question-and-answer period followed the talk, and the meeting adjourned at 10:00 p.m.

—CHARLES D. COREY, *Corr.*

OAK RIDGE

The regular March 4th meeting of the Oak Ridge Section featured a joint discussion by L. E. Emerich and J. F. Schock of Leeds & Northrup Company, Philadelphia. Following dinner at 7:00 o'clock, a short business meeting was conducted by President Novak. Subjects discussed included revision of the constitution and by-laws of the Section and the activities of the National Employment Committee. The speakers of the evening were introduced by C. W. Covey, chairman of the Publicity Committee.

The subject of the evening was "Development of Industrial Recorders—Through the Speedomax." The discussion was illustrated with a great number of slides. Mr. Emerich, Manager of Technical Sales for L&N, spoke first, tracing the development of L&N recorders from 1902 to the present Micromax and Speedomax.

Mr. Schock, the second speaker, presented a comparison between the Micromax, the Speedomax "A" and the Speedomax "G". His discussion also covered the Micromax pneumatic controller as well as circuit diagrams of the Speedomax instruments.

Mr. Schock, Section Head of L&N's Engineering Department, concluded the program by answering questions from the floor. W. A. McCan, Cincinnati representative of L&N Technical Sales, was a guest at the meeting.

Chairman Fisher of the Program Committee announced the subjects and the speakers for the forthcoming meetings, as follows:

April: "New Developments of General Engineering and Consulting Laboratories," by J. L. Michaelson of General Electric Company.

May: "Servomechanisms," by H. A. Straus of Monsanto Chemical Company, Oak Ridge.

June: "Radiosondes—Present Status of the Art," by V. D. Hauk, Chief Engineer of Friez Instrument Division, Bendix Aviation.

—CHAS. W. COVEY, *Corr.*

PITTSBURGH

The February meeting of the Pittsburgh Section was held on Monday, February 24, at the Carnegie Library lecture hall. After a dinner served in the cafeteria, J. E. Davis, director of vocational training, Pittsburgh Board of Education, spoke briefly on a course for instrument mechanics which is under consideration by the Board of Education. He requested that an advisory committee be appointed by the president of the Pittsburgh Section to decide on a method of selecting trainees and to obtain the necessary instruments for demonstration and practice work. President Sam Prince appointed such a committee and instructed them to make a survey of potential trainees and suggested that a night class in this subject should be inaugurated next September.

The members then adjourned to the lecture hall where a technicolor film, "The World's Largest Plate Mill," was presented. This film was produced by the Lukens Steel Company of Coatesville, Pa., and gave a colorful description of the interior of a modern steel plant. Following presentation of the film, a brief business meeting was held during which Al Shafer of the Rules Committee reported an alteration in Article 7 of the Pittsburgh Section rules. This alteration provides that amendments to the rules, after being passed by the Executive Committee, must be ratified by a simple majority of the members present at the

next business meeting. This change was accepted by a voice vote of the members. Since the business of the Rules Committee was terminated by the Section's acceptance of the amended rules, the president extended them the thanks of the Section and dissolved the committee.

R. J. Kryter of the Esterline-Angus Co., Inc., Indianapolis, Indiana, presented the main address of the evening entitled "The Endless Quest—The Application of Electrical Recording Instruments to the Solution of Problems of Industry and Technology." His talk, illustrated by slides, showed ingenious applications of recording instruments in such diversified fields as time study, radio and radar trouble shooting, surveys of telephone and utility demands, opinion meters, automatic landing control, and colorimetry. After a brief discussion period the meeting was adjourned.

The next meeting will be held March 24, 1947. A. F. Benson of the American Meter Co., Inc., Erie, Pa., will address the Section on "Flow Measurement."

The April 28th meeting will feature H. J. Velten of Askania Regulator Co., Chicago, Ill., who will speak on "Automatic Proportioning of Gases and Liquids."

—A. G. YOUNG, *Corr.*

SOUTHERN MICHIGAN

Chicken Charlie's Restaurant, and their fine steaks, furnished the background and atmosphere for a very interesting and enjoyable meeting of the Southern Michigan Section on Wednesday, March 12. Forty-five members and guests were present.

Following the dinner, President Wade Allen welcomed seven new members and a number of out-of-town visitors, and announced the Regional Meeting to be held in Cleveland, April 23-25.

J. R. Frederick, of the University of Michigan, was the speaker of the evening. He gave a very interesting discourse on the "Supersonic Reflectoscope," an instrument which he, in collaboration with Dr. Firestone, developed. Dr. Frederick is still carrying on research work on the instrument, exploring further possibilities for its use.

The Supersonic Reflectoscope is nothing more than an acoustic radar, used to detect flaws in metal or other homogeneous substances—flaws which cannot be readily detected by other means. Its operation is based on the time required for the reflection of a supersonic wave from an oscillator-excited crystal to the flaw and back to a detecting crystal.

The talk was well illustrated with slides, many of which were photographs of oscillograms produced during actual tests. A very lively question and answer period followed the presentation. —KEN MEAD, *Corr.*

TENNESSEE

(Received too late for the March issue.)

The twenty-second meeting of the Tennessee Section was held at the Tennessee Eastman Corporation in Kingsport on February 5, 1947. Members met for dinner at the Kingsport Inn before the meeting.

W. N. Greer of the Leeds & Northrup Company was the speaker of the evening. His subject, "Conductivity and pH Measurements," was well received by the members and their guests. The history and development of the various types of electrodes, as well as the use and limitations of each, was explained in detail. A discussion of the adaptability of these measurements to industrial plants followed Dr. Greer's talk.

No business was conducted at this session, which adjourned at 10:30 p.m.

The next meeting will be held at 8:00 p.m. on Wednesday, March 12, at the Civic Auditorium in Kingsport. The speaker will be J. B. McMahon, of Public Flow Meters Company, Chicago, who will present "A Non-mathematical Discussion of Flow Measurement." —F. H. THEILE, *Sec'y.*

VIRGINIA

Not only Spring was heralded in on the day of March 21st, but a prospective Virginia Section of the Instrument Society. Approximately forty instrument men representing such noteworthy organizations as American Viscose, Calco Chemical, Celanese, Dupont, Institute of Textile Technology, Merck, Phipps & Bird and University of Virginia expressed their interest in forming a Virginia Section by attending a 7 p.m. dinner-meeting at the Monticello Hotel in historic Charlottesville. Some of these men traveled over 120 miles, coming from Narrows, Front Royal, Roanoke and other points throughout Virginia.

After a delicious Southern fried chicken dinner, A. B. Wigley, who has been instrumental in trying to start a Virginia Section, gave a short, informal talk introducing Geo. E. Reeke of Merck & Co., as toastmaster. Mr. Reeke then turned the meeting over to W. A. Wildhack, vice-president of the Washington (D.C.) Section, who gave an entertaining and comprehensive talk describing the principal functions and objectives of the ISA and defining instrumentation as applicable to Virginia's industries.

Mr. Reeke was elected temporary chairman and given the power to appoint temporary officers to draw up by-laws for the new Section.

It was generally agreed at the meeting that the name of the Section would be the Virginia Section and that it would not confine its meetings to any one city, but would hold periodic meetings rotating throughout the principal industrial cities of the State.

The idea of forming a Virginia Section of the Instrument Society was enthusiastically received by all attending the meeting, and each promised to put forth a membership drive so that the next meeting might be much larger and more representative of Virginia's diversified industries.

The time and place for the next meeting is to be announced. Geo. Reeke of Merck & Co., Inc., Elkton, Va., would be glad to furnish any interested persons with membership blanks and extends an invitation to instrument men throughout Virginia to write him if only to request the date and topic of the next meeting.

WASHINGTON

The 29th meeting of the Washington Section was held in the Pepco Auditorium on Monday, February 17. The first speaker of the evening was J. E. Rodenhausen of the United States Gauge Division of American Machine and Metals, Inc. His subject was "Mechanically Actuated Pressure Instruments." Mr. Rodenhausen spoke on the history, design and manufacture of Bourdon tubes and metallic diaphragms, stressing their particular applications for measurement in the industrial and aeronautical fields. Considerable interest was displayed by the number of questions asked.

The second speaker of the program was W. A. Wildhack of the Aeronautical Instrument Section of the National Bureau of Standards. Mr. Wildhack is also a Vice-president of the Washington Section. Bill spoke on the development, in which he was instrumental, of three different types of gages and adapters for making small differential measurements in high pressure lines. The first gage was a plunger [illegible] differential gage made of lucite. The [illegible] was an indicating type mercury gage, [illegible] third was a simple mercury trap for [illegible] ing low pressure gages for high pres[illegible] lines. Before these gages were develo[illegible] Bill had had considerable difficulty [illegible] damage to gages he had been using.

We are pleased to announce that R[illegible] Hadady of the American Instrument C[illegible] pany has been appointed chairman of [illegible] Publicity Committee.

The next meeting, to be held in the P[illegible] Auditorium on Tuesday, March 18, will [illegible] ture A. D. McFayden, Chief of the M[illegible] uring Division, United States Patent O[illegible]

—G. M. ROLLS, *Cor*[illegible]

WAYNE COUNTY

The Wayne County Section held its re[illegible] lar meeting on March 17 at the Pres[illegible] terian Church House in Wyandotte, M[illegible] The dinner was held at 6:30 and the m[illegible]

ISA EMPLOYMENT SERVICE

In printing these announcements the [illegible] ciety assumes no obligation as to respo[illegible] bility of employers. Those replying to [illegible] nouncements should include two copies [illegible] their reply. When testimonial docume[illegible] are to be included, copies of such docume[illegible] and *not* the originals should be sent. [illegible] Society regards acknowledgment by emp[illegible] ers of all applications as an act of cour[illegible] but can assume no responsibility for t[illegible] failure to do so. Address all replies to E[illegible] ployment Committee, Instrument Society [illegible] America, 1117 Wolfendale St., Pittsbu[illegible] 12, Pa.

—C. F. GOLDCAMP, *Chmn. Employ. C*[illegible]

SITUATIONS OPEN

PHYSICIST or ENGINEER for development [illegible] specialized measuring devices for applications [illegible] the food process industry, and for which there [illegible] no available commercially-made instrument. W[illegible] would involve studies of process variables to de[illegible] mine suitable measuring criteria and the devel[illegible] ment of suitable instruments for making th[illegible] measurements. Location Illinois. Box 44.

. . .

PHYSICIST or ENGINEER for long range fu[illegible] mental project in connection with guided mi[illegible] program. Background of research and devel[illegible] ment on instrumentation or automatic con[illegible] equipment required. Position requires the pl[illegible] ning of programs and the supervision of engin[illegible] ing personnel. Permanent position with unlim[illegible] opportunity in expanding engineering organ[illegible] tion. Salary $6000 to $7000 per year. Loca[illegible] Virginia. Box 45.

. . .

PHYSICIST, ELECTRICAL, MECHANICAL E[illegible] GINEER for research laboratory of a well-est[illegible] lished company, to work on the development [illegible] instruments for the measurement and control [illegible] gaseous atmospheres and related equipment. Lo[illegible] tion, Western Pennsylvania. Box 46.

. . .

INSTRUMENT ENGINEER—graduate with [illegible] perience in controls for experimental work on [illegible] ing automatic, hydraulic and electrical inst[illegible] mentation used in process industries. Must h[illegible] creative mind and ability to assimilate and fol[illegible] through to completion any new assignments. [illegible] 47.

. . .

INSTRUMENT MECHANIC (not supervis[illegible] for installation and maintenance of control equ[illegible] ment such as air-operated controllers, electric c[illegible] trol devices, potentiometers and flow meters. Lo[illegible] tion New Jersey. Box 48.

Plan Now To Attend ● **1947 I. S. A. CONFERENCE AND EXHIBIT**
September 8-12, 1947 **Stevens Hotel, Chicago**

at 8:00 p.m. Approximately 35 attended. The meeting was opened by the drawing for the door prize, which was won by R. Attner.

E. Gambrill, President of the Detroit ction, was a guest at this meeting and nounced the speakers and subjects for e March 24th meeting.

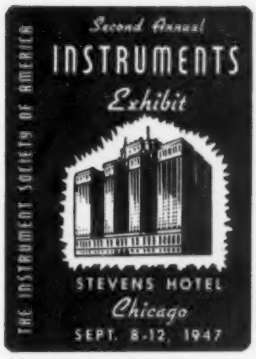
Bill Baker, delegate, reminded those ent of the Regional Meeting to be held Cleveland April 23, 24 and 25, and urged who could to attend. The members were advised to make early plans for the nd National Conference and Exhibit to held in Chicago in September.

President John MacPherson then turned meeting over to the program chairman, eorge Huff, who introduced the speaker of the evening, W. H. Kidd of the Foxboro Company. Mr. Kidd gave a very interesting talk on "Control Valve Characteristics." He explained very thoroughly the importance of considering line drop as well as valve pressure drop in designing a control installation. The various types of valve construction and their applications were covered. The talk was illustrated with a number of interesting slides.

Our next meeting will be held on April 12 at which time H. W. Aurez will present a talk on "Automatic Control." The annual election of officers will be held at this time.

The May meeting will be held on May 19. The speaker will be T. A. Cohen, and his subject will be "Electronic Control."

—W. G. BAKER, *Corr.*



Who's Who in the I. S. A.

CARL F. KAYAN

The "officer of the month" is our genial First Vice-President, Carl F. Kayan, Professor of Mechanical Engineering Columbia University, New York City. Professor Kayan was born in New York City in the year 1900 and obtained his education in that city, finishing with degrees of A.B. in 1922 and M.E. in 1924, both from Columbia University.

Carl's professional activities include thermodynamics and heat-power applications, and, more recently, Instrumentation. He has been very active in instrument education, having instituted a general course in "Indication and Control" at Columbia more than ten years ago. He is the author of numerous papers on applications of the Electrical Analogger, developed as an analogy instrument for prediction of heat and fluid flow under complex conditions.

Professor Kayan was one of the speakers at the 1945 Carnegie Institute Conference on Instrumentation, as many of our readers remember. He is also the author of the paper "Heat Flow and Temperature Analysis of Complex Structures through Application of the Electrical Resistance Concept," presented at the 6th International Congress for Applied Mechanics, Paris, September, 1946. His special interest is in the development of special purpose instruments for the problems of flow and measurement.

Professional and technical societies include Tau Beta Pi, Sigma Xi, A.S.M.E. (past chairman, Process Industries Division; chairman, Heat Transfer Division; member of the Industrial Instruments and Regulators Division, Theory and Papers Committee; chairman, Membership Committee), A.S.R.E. (past chairman, Research Committee; past chairman, New York Section; member various committees), A.S.H.V.E. (member various committees), the Refrigeration Research Council, the Scientific Adv. Council, past-president of the New York Society for Measurement and Control (1945-47) which is now the New York Section of the Instrument Society of America. Carl was very active in the formation of the I.S.A., serving as pro-tem vice-president during the year preceding the election of regular officers in September, 1946. He was elected First Vice-President at the Board of Directors' meeting held at the time of the First Annual Instrumentation Conference and Exhibit in Pittsburgh last September.

Carl is married and has two daughters, Cynthia and Julia. Incidentally, he first met his wife, Barbara, in Alaska while they were busy surviving the rigors of a shipwreck! Carl used to indulge in his hobby of mountain climbing, but he claims that those days are over. However, he still considers himself an "armchair mountaineer" and occasionally looks back with considerable satisfaction on his records of Mont Blanc, Mount Ranier, and the Matterhorn.

RALPH D. WEBB

Charleston's delegate to the I.S.A. Board of Directors comes from the banks of the old Mississippi river where he was initiated into things mechanical in his father's motor boat and engine shop. Born in Alton, Illinois, in 1897, he grew up there, spending all of his spare time with boats and gasoline engines, digressing from this activity long enough in 1910 to build a 36-inch model "aeroplane" that actually took off from the ground and flew. Again in 1916, aircraft distracted him, for he built a 22-foot glider that wasn't stable, the homemade turnbuckles proving inadequate in moments of stress.

World War I found him desperately trying to get into the Army. Seven times he was rejected, three of these by the Air Force, then a part of the Signal Corps, but, in February of 1918, he persuaded the draft officials to send him to camp. Two weeks before his 21st birthday he was discharged as an enlisted man and commissioned a 2nd Lt. of Infantry as a machine gun specialist.

Army life was followed by 21 months of varied experience in an Illinois oil refinery, and that by four years at the University of Illinois where he was granted a B.S. in Mechanical Engineering in 1924. His social fraternity was Acacia, and his professional and honorary fraternities were Sigma Tau, Pi Tau Sigma, and Tau Beta Pi.

He started working for Carbide and Carbon Chemicals Corporation immediately upon graduation and is still with them. Three weeks at their semi-commercial plant at Clendenin, W. Va., then five years in Oklahoma and adjoining states erecting, operating, and surveying for natural gasoline depropanizing columns, then four years of operation at the company's methanol and dry ice plant at Niagara Falls, after which he returned to West Virginia in 1933 to take over the six-man "Meter Department" of the rapidly growing South Charleston plant. Under his supervision, the "Meter Department" grew into the "Instrument Department" and recently into the Instrument Division," consisting of a "Plant Instrumentation Department," an "Instrumentation Engineering Department," and a "Special Instrumentation Department" with the total membership of the three departments being 96 persons.

Ralph is a member of A.S.M.E., A.I.Ch.E., W. Va. Society of Prof. Engineers and, of course, I.S.A. He is also a registered professional Mechanical Engineer. He served as chairman of the W. Va. Section of A.S.M.E. for 1944-1945. He attended the first meeting of the committee that grew into the Instruments Division of A.S.M.E. and is now chairman of the Division's Committee on Application. He served as Chairman of the 1945 Gibson Island Instrumentation Conference and is at present a member of the Executive Committee of the Instrument Section of the Chemical Research Conferences. He has been active in I.S.A. since its inception and feels that his main contribution to it was his chairmanship of its first National Nominating Committee, where he endeavored to establish procedure and set traditions that would assure the Society's being operated in a democratic manner.

The Webbs have a daughter in college and a son in high school.

C. F. GOLDCAMP

"Cy" Goldcamp is chairman of one of the most important and, at present, most active committees of the Society—the Employment Committee. He has set up and is now operating the Central Registration Bureau for this committee in his office in Pittsburgh, where he is Sales Manager for Instruments Publishing Company, currently the national headquarters of the I.S.A.

Cy was born at Ironton, Ohio, on February 9, 1898. His education includes a B.S. degree in Chemical Engineering from Lehigh University, Bethlehem, Pa., and several years of post-graduate (night school) study in Metallurgy at Carnegie Institute of Technology, Pittsburgh, Pa. After overseas service with the U. S. Army Tank Corps in World War I, Cy finally settled down with Jones & Laughlin Steel Corporation, Pittsburgh, serving for over twenty years in various capacities including Chief Inspector, Metallurgical Engineer, and Manager of Sales of the Bar Division. In February of 1945, he joined the Instruments Publishing Company as Sales Manager.

Besides being chairman of the Employment Committee, Cy is also a member of the Sections Committee. He is a member of the Cleveland Section at present. He is married, has one son also married, and one granddaughter. His hobbies, when he has time to indulge, include golf and "keeping a scrap-book of his granddaughter."

Technical Society News

BOSTON INSTRUMENT SOCIETY

The sixth meeting of the Boston Instrument Society was held at Thompson's Spa in Boston on Wednesday evening, March 26, 1947.

A roast beef dinner was served at 6:30 p.m., and at 8 p.m., Mr. H. S. Fairchild introduced Mr. C. B. Moore of the Moore Products Co., Philadelphia, Pa., who talked on "The Solution of Instrumentation Problems by the Pneumatic Null Balance Method."

The members present, who numbered about seventy, enjoyed the interesting address by Mr. Moore.

At the April 9th meeting at Thompson's Spa Mr. McMahon of the Republic Flow Meters Co., and Chairman of the Committee on New Sections of the I.S.A., will address the meeting on "The Force Balance Method of Measuring." He will talk also on the subject "Shall We Join the I.S.A.?"

J. H. CONDON, *Corr. Sec.*

HARTFORD SOCIETY FOR MEASUREMENT AND CONTROL

Roger F. Waindle of the Elgin National Watch Co. will give a talk entitled, "Sapphires Used in Industry" at the April 16th meeting of the Hartford Society for Measurement and Control. The meeting will be held at the City Club, Hartford, with a dinner at 6:30 p.m. and the technical session at 8:00 p.m.

The Annual Meeting of the Society will be held May 21st.

SOUTHERN CALIFORNIA METER ASSOCIATION

The next meeting of the Southern California Meter Association will be held April 17th at the Rio Hondo Country Club, Downey, Calif. Dinner will be at 6:30 p.m. with the technical session at 8:00 p.m.

AUTOMATONS EXCEL HUMANS IN FLYING MODERN PLANES

NEW YORK, N. Y.—Limited human capabilities are necessitating increasing reliance upon automatic controls for aircraft, the National Aeronautic Meeting of the Society of Automotive Engineers was told at its opening session in Hotel New Yorker. The modern plane's bewildering arrays of indicators and gages, of switches and levers, coupled with its tremendous speed, extreme size, and decreasing stability, were described as logical causes of "panel panic" whereby pilots can become rattled at critical times with fatal results. Automatic controls were said to handle engines, flight, navigation, and even traffic control better than humans and without fatigue or error.

High engine efficiency requires more precise control than a busy human pilot can provide, it was reported by Hugo Schuck and Gordon Volkenant, of Minneapolis-Honeywell Regulator Co. They described an automatic device employing a single lever to coördinate four engines, a flame detector coupled to a fire extinguisher and an ice detector which automatically starts deicing equipment. Development and use of the electronic autopilot was said to be making flight control an effortless task and to permit additionally of directional control, automatic trim, automatic altitude selection, constant airspeeds, and automatic "hands off" landings.

Trouble-free electrical systems designed to meet specific needs are as essential as wings to modern transport aircraft, the meeting was told by E. P. Buckthal, of United Air Lines.

Experimental determination of actual load strains and stresses on aircraft wheels and brakes—one of the most complicated load combinations in existence—was described by Marvin H. Polzin of Goodyear Aircraft Corp.

X-RAY DIFFRACTION COURSE

A course in X-ray Diffraction and Spectrometry will be given April 21-25 at the New York offices of North American Philips Co., located at 100 East 42nd Street. Lectures daily, followed by laboratory work and question and answer periods. Beginning on April 24, special subjects and advanced techniques: those interested in this phase of the work need only devote two days to the project. Lecturers: Dr. M. J. Buerger, Dr. I. Fankuchen, Dr. Herbert Friedman, Dr. Kathleen Lonsdale, Dr. William Parrish and Dr. Ralph Wyckoff.

NEW ENGLAND RADIO ENGINEERING MEETING

The newly created North Atlantic Region of the Institute of Radio Engineers will sponsor an all-day radio engineering meeting at the Hotel Continental, Cambridge, Mass., Saturday, May 17. This date is a postponement of an earlier date previously announced.

Scheduled are six technical papers to be presented for the first time, on communications, micro-waves, frequency modulation and measurements. None of these papers will be given concurrently. A large space in the Hotel Continental will be devoted to a number of exhibits of radio and electronic products manufactured only in this region.

Advanced registration is essential, since facilities are limited. Write to H. H. Dawes, New England Radio Engineering Meeti 275 Massachusetts Avenue, Cambridge Mass.

AMERICAN AERONAUTICAL INDUST NOW USING DECIMAL DIMENSIONI

NEW YORK, N. Y.—Decimal dimensi ing, affording major benefits of the me system without simultaneously creati wholesale disruptive conversion headach increasingly is being used by the Americ aeronautical industry. Survey by the Ae nautical Drafting Committee of the Soci of Automotive Engineers, made among a lines operators and manufacturers of plan powerplants, propellers, and accessories, d closes that 80% now employ decimal dim sioning or contemplate its early adopti Users explain that the practice of expre ing limited measurements in decimals rat than fractions of inches contributes to spe and to accuracy both in design and in man facture. Decimals are carried to two, thr or more, places to satisfy varying toleran requirements.

The practice is characterized as maki the dimensioning of drawings much eas and more rapid and as being especially he ful in eliminating the time-consuming, err producing operations of converting decim to fractions and back to fractions aga Furthermore, tolerances may be indicat merely by extending digits after the decim point.

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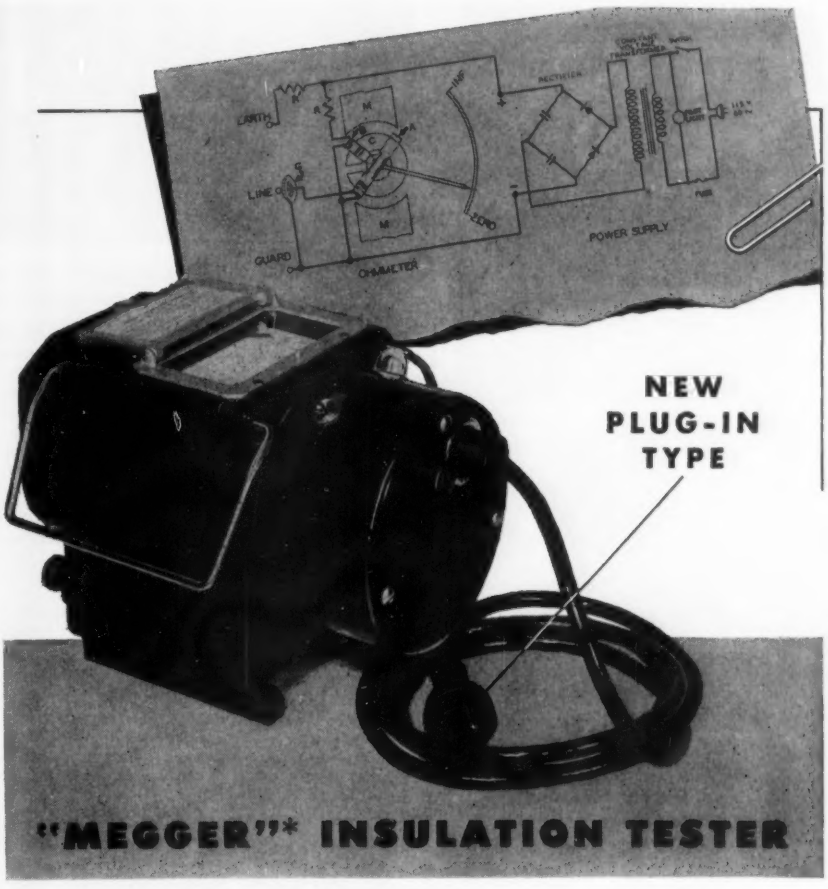

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5. Testing control and power circuits in railway signal installations.
6. Production testing of all types of electrical equipment and components.
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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from t manufacturers. We urge readers to request ONLY those bulletins which will be of value them. Use the Postage-free Order Card on page 387.

O-132 **Ignition Velocity Meter.** 6-page 8½" × 11" Bulletin No. 2012 pictures and describes the "Hays Ignition Velocity Meter" (Dr. Dommer type) for determining and checking flame characteristics of gases in gas plants and other uses. The Hays Corp., Michigan City, Ind.

O-133 **"Electronic-Pneumatic-Mechanical Instrumentation."** 32-page 8½" × 11" Vol. 2 No. 4 of this house organ contains ten articles about various phases of industrial instrumentation. The Brown Instrument Co., Wayne & Roberts Aves, Philadelphia 44, Pa.

O-133a **Gage Blocks.** 16-page 3" × 6" Folder Form 7096 pictures and describes maker's line of gage blocks and accessories. Gives methods of use, applications and instructions for care of gage blocks. Ford Motor Co., Johansson Div., 3650 Schaefer Rd., Dearborn, Mich.

O-133b **Radio Tube Technical Manual.** 384-page 5" × 9" manual contains technical information on all available types of radio tubes. Also includes fundamental electrical laws, properties of vacuum tubes, and information on maker's other products. Available for 85c. Sylvania Electric Products, Inc., Emporium, Pa.

O-134 **Engine Indicator.** 4-page 8½" × 11" bulletin pictures and describes the "DeJuhasz" engine indicator for diesel, steam and gas engines and compressors. Kalman J. DeJuhasz, Mech. Eng., 730 N. Atherton St., State College, Pa.

O-135 **Temperature Regulators and Controllers.** 24-page 8½" × 11" Bulletin 464 pictures and describes maker's temperature regulators and controllers for process heating and cooling. Capacity tables are included. Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.

O-136 **Can Mobilometer.** 6-page 6" × 9" bulletin pictures and describes the "Can Mobilometer" for measuring mobility and consistency of materials in their original containers. Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda, Md.

O-137 **"The Graphic."** 8-page 8½" × 11" issue of this house organ designated Bulletin No. 442 is devoted to an article entitled, "Graphic Instruments Help to Improve Highway Safety." Esterline-Angus Co., Inc., Box 596, Indianapolis 6, Ind.

O-138 **Chronometric Tachometers.** 4-page 8½" × 11" Bulletin No. 735 pictures and describes "Jacquet Indicators" in 4 ranges for speeds from 0 to 100,000 rpm. Herman H. Sticht Co., Inc., 27 Park Place, New York, N. Y.

O-139 **Flowmeter.** 2-page 8½" × 11" Bulletin No. 876 pictures and describes the "Cox Type 10 Flowmeter" for measurement of small fluid flow rates. Commercial Research Laboratories, Inc., 20 Bartlett Ave., Detroit 3, Mich.

O-140 **Temperature Instruments.** 12-page 8½" × 11" Bulletin 230-B pictures and describes the "Pyrotron" electron resistance thermometer available in ind cating, recording or controlling mode Bailey Meter Co., 1050 Ivanhoe R Cleveland 10, Ohio.

O-141 **Pumps.** 32-page 8½" × 11" Cat log No. 146 pictures and describes make line of pumps in controlled volum chemical and high-pressure types. I cludes tables for selection of prop style and materials of construction. M ton Roy Pumps, 1300 E. Mermaid Av Philadelphia, Pa.

O-142 **"Cenco News Chats."** 24-pag 8½" × 11" Issue No. 54 of this hou organ contains a short article on th achievements of Charles P. Steinmet Also includes descriptions of several ne laboratory instruments. Central Scientif Co., 1700 Irving Park Rd., Chicago 1 Ill.

O-143 **"The Oscillographer."** 4-page × 9" Vol. 8 No. 1 of this house orga features an article entitled "Valve Ge Problems." Allen B. DuMont Labs., In Passaic, N. J.

O-144 **Infrared Gas Analyzer.** 2-pag 8½" × 11" Bulletin 5MC pictures and de scribes maker's infrared gas analyze an industrial-type instrument for co tinuous measurement, detection and co trol. Baird Associates, University Rd Cambridge, Mass.

O-146 **Plumb Bob.** 2-page 8½" × 1 bulletin pictures and describes th "Micro" precision plumb bob. Suverkro Instruments, P. O. Box 436, Bakersfiel Calif.

O-147 **Tachometers.** 20-page 8½" × 1 Bulletin 1810 pictures the "Frahm" li of vibrating-reed tachometers for ind cating speed and frequency of vibratio James G. Biddle Co., 1316 Arch St., Phil delphia 7, Pa.

O-148 **Miniature Switches.** 24-page 8½ × 11" catalog pictures and describes th large number of styles and sizes of "Mi Switches" available. Mu-Switch Corp Inc,. Canton, Mass.

O-149 **"The Laboratory."** 32-page 6" 9" Vol. 16 No. 4 of this house organ fe tures an article on laboratory first a and fire fighting. Fisher Scientific Co 717 Forbes St., Pittsburgh 19, Pa.

O-150 **Automatic Control Valves.** page 8½" × 11" bulletin pictures an describes maker's automatic contr valves in temperature- or pressure-actu ated types. Douglass Automatic Control Co., 4505 E. Firestone Blvd., South Gat Calif.

O-151 **Low-resistance Test Sets.** 4-pag 8½" × 11" Bulletin LRT-1 pictures an describes maker's low-resistance te sets for testing bond and other resis ances as low as 0.000002 ohms again a predetermined standard. Shallcro Mfg. Co., Jackson & Pusey Aves., Collin dale, Pa.

O-152 **Hydraulic Cylinders.** 20-page ½" × 11" Bulletin No. 35-B pictures and describes maker's line of high-pressure hydraulic cylinders for all classes of hydraulic power applications. Hannifin Mfg. Co., 621 S. Kolmar Ave., Chicago, Ill.

O-153 **"The C-D Capacitor."** 16-page × 9" Vol. 11 No. 10 of this house organ features two articles: "Phase Inverter Circuits," and "Receiver Input Circuits." Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

O-154 **Square-wave Generator.** 2-page ½" × 11" Page 110 of Electronic Specialties Manual pictures and describes "Type SG-13" square-wave generator. General Electric Co., Electronics Dept., Schenectady, N. Y.

O-155 **Water Purity Indicator.** 2-page ½" × 11" Bulletin 115 pictures and describes the "Model No. PM2 Purity Meter" for checking the purity of distilled water. Barnstead Still & Sterilizer Co., Inc., 2 Lanesville Terrace, Boston 31, Mass.

O-156 **Surveying Instruments.** 20-page " × 10" bulletin pictures and describes maker's line of engineering, surveying and mining instruments. C. L. Berger & Sons, Inc., 37 Williams St., Boston 19, Mass.

O-157 **Weather Instruments.** 48-page ½" × 11" catalog pictures and describes maker's line of weather instruments including anemometers, thermometers, psychrometers, etc. M. C. Stewart, Ashburnham, Mass.

O-158 **"Burrell Announcer."** 16-page ¼" × 8½" Issue No. 47-1-25 of this house organ features an article entitled, "Laboratory Glassware, a Review of Interesting Facts." Also pictures and describes several new laboratory instruments. Burrell Technical Supply Co., 1936 5th Ave., Pittsburgh 19, Pa.

O-159 **Tachometers.** 16-page 8½" × 11" Catalog 146 pictures and describes maker's line of tachometers in continuous indicating, portable and fixed types. Jones Motrola Corp., Stamford, Conn.

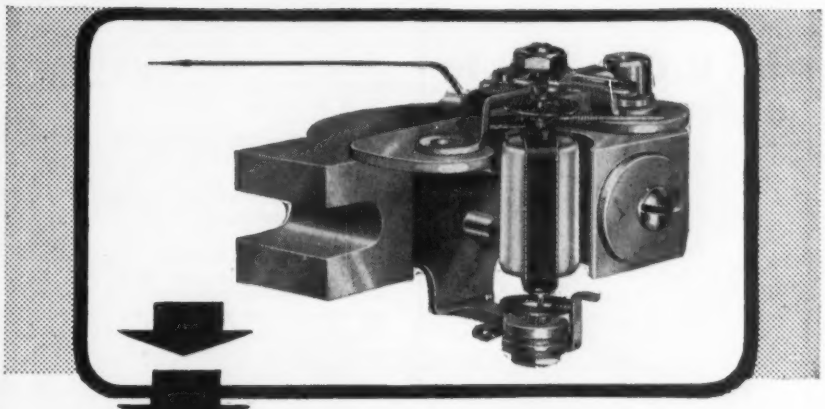
O-160 **Light-wave Measuring Equipment.** 160-page 6" × 9" Catalog and Handbook No. 33 pictures and describes maker's light-wave measuring equipment and precision measuring tools, and gives data on their use. The Van Keuren Co., 12 Copeland Ave., Watertown, Boston, Mass.

O-161 **Diaphragm Control Valves.** 24-page 8½" × 11" Bulletin No. 500 pictures and describes "Model 700" diaphragm control valve in a number of types. H. Belfield Co., 435 N. Broad St., Philadelphia, Pa.

O-162 **Pump Governors.** 16-page 8½" × 11" Bulletin 463 gives engineering, operating and maintenance data on maker's line of governors for reciprocating, turbine and motor-driven pumps. Leslie Co., 225 Delafield Ave., Lyndhurst, N. J.

O-163 **Vitreous Enamel Resistors.** 8-page 8½" × 11" Bulletin VER pictures and describes maker's line of fixed and adjustable vitreous enamel power resistors. P. R. Mallory & Co., Inc., Indianapolis 6, Ind.

O-164 **Aircraft Instruments.** 8-page 8½" × 11" bulletin pictures and describes maker's line of aircraft instruments including air speed indicators, rate of climb indicators, compasses, clocks, ice warning indicators, fuel level gages, altimeters, etc. Aeromarine Instrument Co., 385 Gerard Ave., New York 51, N. Y.



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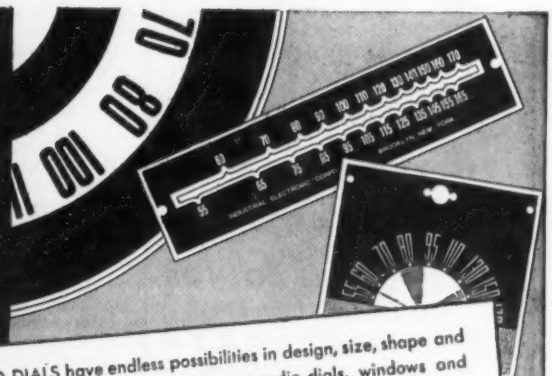

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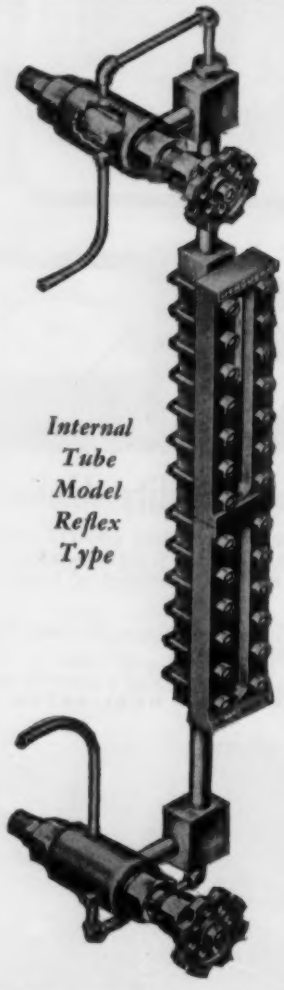

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O-165 **Twin-chart Recorder.** 4-page 8½" × 11" bulletin pictures and describes "Model RZ Twin Graphic Recorder," and "Model DS" stabilized power supply. Sound Apparatus Co., 233 Broadway, New York 7, N. Y.

O-166 **D-c Bridges.** 6-page 8½" × 11" Bulletin D-2 pictures and describes maker's line of d-c. bridges in several types, and power supply units. Shallcross Mfg. Co., Collingdale, Pa.

O-167 **Thermometers.** 6-page 4" × 8" bulletin pictures and describes line of mechanical thermometers for steam or hot water, and a recording thermometer. Standard Thermometer, Inc., 952 Dorchester Ave., Boston, Mass.

O-168 **Heavy-duty Relays.** 4-page 8½" × 11" Bulletin No. 30 pictures and describes maker's heavy-duty, multiple-arm relays in several models. Signal Engineering & Mfg. Co., 152-8 W. 14th St., New York 11, N. Y.

O-169 **Remote Controls.** 8-page 8½" × 11" bulletin pictures and describes several types of maker's remote controls and discusses their application to various control problems. Yardeny Laboratories, Inc., 105 Chambers St., New York 7, N. Y.

O-170 **Gage Blocks.** 8-page 8½" × 11" Bulletin 46-P pictures and describes maker's carbide and steel gage blocks and shows applications. Fonda Gage Co., 53 Daly St., Stamford, Conn.

O-171 **Adjustable Flush Pin Gage.** 4-page 8½" × 11" Bulletin Form G-100 pictures and describes an adjustable flush pin gage, said to replace dozens of fixed gages. Schnacke, Inc., 1016 E. Columbia St., Evansville 7, Ind.

O-172 **Modulation Meter.** 4-page 8½" × 11" Bulletin EC-28 pictures and describes "Type X-7018" modulation meter for monitoring percentage modulation of AM radio transmitters. Sylvania Electric Products, Inc., 500 5th Ave., New York 18, N. Y.

O-173 **Tube Socket Guide.** 32-page 5" × 7" booklet lists in tabular form the proper sockets for all available types of electron tubes. Also pictures and describes maker's line of tube sockets. E. F. Johnson Co., Waseca, Minn.

O-174 **Power Supply Units.** 4-page 8½" × 11" bulletin pictures and describes power supply units in six models for testing purposes. Arthur E. Booth Co., 210 W. 7th St., Los Angeles 14, Calif.

O-175 **Molded Resistors.** 4-page 8½" × 11" Bulletin 4505 pictures and describes maker's line of "All-Weather" molded resistors for use in precision electronic equipment. S. S. White Dental Mfg. Co., 10 E. 40th St., New York 16, N. Y.

O-176 **Leak Locator.** 2-page 8½" × 11" bulletin pictures and describes the "Globe Phone" for locating underground leaks in water, sewerage and steam pipes. Globe Phone Mfg. Corp., Reading, Mass.

O-177 **Electronic Counter.** 8-page 8½" × 11" bulletin gives fundamental principles and describes applications of the "Lectro-Count" electronic counter. Includes circuit diagrams. Lansing Engineering Co., 934 Clark St., Lansing 5, Mich.

O-178 **Test Instruments.** 24-page 8½" × 11" Catalog 129 pictures and describes maker's complete line of radio, electronic and electronic test instruments. Radio City Products Co., Inc., 127 W. 26th St., New York, N. Y.

O-179 **Measuring Instruments, Tools and Gages.** 96-page 6" × 9" catalog pictures and describes maker's line, including laboratory instruments, machinist's tools, measuring instruments, optical equipment, toolroom specialties, speed transmission equipment and gears. George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.

O-180 **Flow Gages.** 12-page 8½" × 11" Bulletin 42-562 pictures and describes maker's diaphragm-type flow gages for indicating and recording types for low pressure air or gas. The Hays Corporation, Michigan City, Ind.

O-181 **Hydraulic Pressure Gages.** Single sheet 8½" × 11" pictures and describes maker's piston-type hydraulic pressure gages in six scale ranges. Mansfield & Green, 1051 Power Ave., Cleveland 14, O.

O-182 **Corrosion-proof Terminals.** 4-page 8½" × 11" Bulletin 36 describes the methods used for corrosion-proofing maker's terminals and lists typical applications. Aircraft-Marine Products Inc., 1523 N. 4th St., Harrisburg, Pa.

O-183 **"The Aerovox Research Worker."** 4-page 8½" × 11" Vol. 18 No. 12 of this house organ contains an article entitled "The Rectifier-amplifier V.T. Voltmeter." Aerovox Corporation, New Bedford, Mass.

O-184 **Solenoid Valves.** 32-page 8½" × 11" catalog pictures and describes maker's line of solenoid valves in single, double and triple types. Includes color charts of the direction of oil flow through ports of the various types. Sundstrand Pump Div., 2531 11th St., Rockford, Ill.

O-185 **Power & Gas Tubes.** 16-page 8½" × 11" Bulletin Form PG-101 pictures and describes maker's line of power and gas tubes for radio and industry, including

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O-186 **Colorimeter.** 4-page 8½" × 11" pamphlet No. 1323 pictures and describes maker's pre-calibrated clinical photoelectric colorimeter and accessories. E. Leitz, Inc., 304 Hudson St., New York 14, N. Y.

O-187 **Electrical Pressure-measuring system.** 4-page 8½" × 11" bulletin pictures and describes the "Pressuregraph" system for on-the-spot measurement of pressures ranging from 0 to 10,000 lb./in.². Electro Products Labs., 549 W. Randolph St., Chicago 6, Ill.

O-188 **"The C-D Capacitor."** 16-page 6" × 9" Vol. 11 No. 12 of this house organ is devoted to an article entited "The Oscillograph—How to Use It." Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

O-189 **Variable Resistors.** 12-page 8½" × 11" bulletin pictures and describes maker's line of carbon and wire-wound variable resistors. P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.

O-190 **"The Ohmite News."** 2-page 8½" × 11" January 1947 issue of this house organ contains a biography of Reginald Aubrey Fessenden. Ohmite Mfg. Co., 4835 Tournoy St., Chicago 44, Ill.

O-191 **Photoelectric Instruments.** 24-page 8½" × 11" Bulletin 104A pictures and describes the "Cenco-Sheard-Sanford Photelometers," "Cenco-Sheard Spectrophotelometers" and the "Beckman Spectrophotometer." Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

O-192 **Pressure-reducing Valves.** 4-page 8½" × 11" bulletin pictures and describes the "Type A-31" small volume pressure-reducing valve and maker's facilities for engineering valves for special applications. A. W. Cash Valve Mfg. Corp., 666 E. Wabash Ave., Decatur, Ill.

O-193 **Rotameter Dimension Drawings.** 3-page 8½" × 11" Catalog Section 27-A is a complete set of dimension drawings of all available combinations of the "Series 700 Flowrator." Fischer & Porter Co., Hatboro, Pa.

O-194 **Protective Equipment for Internal Combustion Engines.** 32-page 8½" × 11" Catalog No. 646 pictures and describes maker's line of protective equipment for internal combustion engines, including safety controls, alarm systems, special indicator systems, etc. Viking Instruments, Inc., East Haddam, Conn.

O-195 **Automatic Controllers.** 52-page 8½" × 11" Catalog No. 52C pictures and describes maker's line of automatic controllers for pressure, temperature and flow. Includes engineering information and dimensional drawings. General Controls Co., Box 1431, Glendale 5, Calif.

O-196 **Thickness Detector.** 4-page 8½" × 11" bulletin pictures and describes the "Audigage" for measuring from one side the wall thickness of steel pipes and tanks, closed glass containers, ship hulls, etc. Bransom Instruments, Inc., Joe's Hill Rd., Danbury, Conn.

O-197 **Safety and Relief Valves.** 112-page 8½" × 11" Catalog No. 104 pictures and describes maker's line of safety and relief valves. Crosby Steam Gage & Valve Co., 165 Broadway, New York 6, N. Y.

O-198 **Pressure Gages, etc.** 124-page 8½" × 11" composite catalog pictures and

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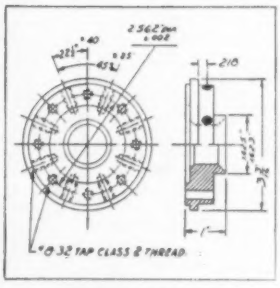

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describes maker's line of products including steam and air gages, dead-weight gage testers, wheel press recording gage, pop safety and relief valves, and related accessories. The Ashton Valve Co., 161 First St., Cambridge 42, Mass.

O-199 **Mass, Volume and Length Standards.** 28-page 6" × 9" Bulletin No. 1500 pictures and describes maker's line of precision standards of mass, volume and length for use by weights and measures officials and others. W. & L. E. Gurley, Troy, N. Y.

O-200 **Machinists' Measuring Instruments.** 20-page 8½" × 11" catalog pictures and describes maker's line of tools including squares, protractors, calipers, dividers, thickness gages, depth gages, thread gages, rules, etc. Union Tool Co., Orange, Mass.

O-201 **"Electronic-Pneumatic-Mechanical Instrumentation."** 32-page 8½" × 11" Vol. 2 No. 3 of this house organ contains several articles on the applications of instrumentation to industry, including: "Process Control at Westinghouse East Pittsburgh Works," "Instrumenting the Dow Process for Styrene Production," "Automatic Control of a Fluid Catalytic Cracking Unit," and others. Brown Instrument Co., Wayne and Roberts Aves., Philadelphia 44, Pa.

O-202 **Hermetic Terminals.** 16-page 8½" × 11" Catalog C-4 pictures and describes the "Fusite" glass-to-metal terminals and the "HermetiCan" for hermetically sealing electrical components. Cincinnati Electric Products Co., Carthage at Hannaford, Cincinnati 12, Ohio.

O-203 **Photoelectric Colorimeter.** 12-page 8½" × 11" Bulletin No. 460 pictures and describes the "Evelyn Photoelectric Colorimeter," a stabilized direct-reading single-photocell photoelectric photometer equipped with light filters. Rubicon Co., Ridge Ave. and 35th St., Philadelphia, Pa.

O-204 **"General Radio Experimenter."** 8-page 6" × 9" Vol. 21, No. 7, of this house organ contains an article, "Those Iron-cored Coils Again," which brings up-to-date the article, "How Good Is an Iron Cored Coil," published in March 1942 issue. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

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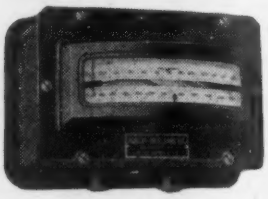

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